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URNATELLA GRACILIS LEIDY, A LIVING TREPOSTOMATOUS BRYOZOAN

GEORGE B. TWITCHELL

"Man möchte also glauben, dass einfache Stammformen zwei wichtige Eigenschaften in sich vereinen, nämlich die Fähigkeit, zahlreiche verschiedenartige Zweiggruppen zu bilden und doch den grösseren Teil ihrer Nachkommen zu überleben."—JOH. WALTHER.

I.—Introduction

The Trepostomata are not included in what German paleontologists call the "Dauerfossilien;" they are supposed to have long been extinct. Nor are they classed among the "problematica;" for when some fifty years ago they were removed from the dubious tabulate corals to be classed with the bryozoans, paleontologists seemed to feel that *finis* had been written to any essential problem their structure might present. But to relegate an organism to the bryozoans is far from determining its affinities; for this phylum or subphylum is made up of groups, two of which are believed to be extinct, that show but little relationship to each other. The differences go so far that it has even been suggested that the Entoprocta should be removed from the rest of the bryozoans and placed in a separate subphylum or phylum. Indeed, simply to include a group of fossils in such a class of varied organisms is like saying that an oak is a forest tree. Our aim must be to be more definite in classification, for if we fail to find in the group any relationship to the living members of the class to which we relegate it, we are dealing with organisms having purely hypothetical functions, lack of comparison with living animals compelling us to invent uses for the organs that have been preserved in the fossils.

This has been the case with the Trepostomata. In this paper I shall present strong reasons for assigning the Trepostomata to the Entoprocta. Through the study of the homologies that exist in fossil and modern forms, insight is gained into the life histories of the fossil forms and into the functions of organs heretofore problematical. But more than that: we discern the outlines of one more race history which illustrates the rise and fall of an important group of invertebrates.

The history of life not infrequently records instances of the primitive founders of a phylum continuing as "living fossils" long after the extinction of its highly elaborated branches. The Paleozoic Trepostomata included

hundreds of species belonging to many widely differing genera and classes. The Entoprocta of today are represented by about two dozen species grouped in three families made up of a few genera. All are marine with the exception of *Urnatella*.

The living Entoprocta thus present the picture of a relic race. It remains to be shown that they are relics of the once important Trepostomata.

We naturally look in the early paleontological records for ancestral forms, but we must not expect to find anything not capable of preservation. In most instances, moreover, the fossils we study are forms that by coenogenesis have digressed far from the simple ancestral type by developing organs, endo- and exoskeletons, capable of fossilization.

For the study of basic relationships we therefore are often dependent on the presence of relic races in the midst of modern life: of true "living fossils," survivors of ancestral forms that lacked hard parts capable of preservation in the paleontological record. All such forms should be studied again and again with the utmost care. The importance of such studies can not be emphasized too often nor too strongly.

In this paper the Entoprocta will be considered as survivors of early stages of actual bryozoans; that is, of bryozoans that had just arrived, and which therefore differ greatly from the highly evolved modern or even fossil bryozoans, principally in the retention of what seem to be relic organs.

The close relationship between the Entoprocta and the Ectoprocta is fully discussed by Davenport, who concludes from a careful review of all that is known of the structure of the Entoprocta that "if morphological principles can be relied upon, Entoprocta are nearer the ancestral form of Bryozoa than Ectoprocta."[1]

Urnatella gracilis Leidy, the freshwater entoproct, differs from other Entoprocta in having, among other features, "a water or excretory system ending in flame cells." This points "conclusively to an origin of Bryozoa from the lowest worms. For such an excretory system is found elsewhere only in Platyhelminthes, Rotifera, and in a modified form in Nemertines."[2] Hence *Urnatella* may be considered the lowest of the Entoprocta, the lowest of the bryozoans, and a relic of the stage in which the first bryozoans had developed from the lowest worms.

It is significant that this most primitive of all bryozoans is found living today in fresh water. Streams and lakes harbor so many survivors of earlier stages of life that this association alone might be used as an argument in favor of the relic character of *Urnatella*.

Typically, the stocks of the *Pedicellinidae*, to which *Urnatella* belongs, consist of stolons or a basal plate, from which two or more segmented stalks arise,[3] each terminating in the polypide proper. Not only these major units of the anatomy but a number of other specific details of their structure have

1 Davenport, C. B., On Urnatella gracilis, Bull. Mus. Comp. Zoology, Harvard College, vol. 24, p. 33, 1893.

2 ibid. p. 33.

3 See, for instance, the discussion in Ehlers, E., Zur Kenntnis der Pedicellineen, Abh. Königl. Ges. d. Wiss. Göttingen, Phys. Kl., vol. 36, pp. 137-145, 1890.

exact counterparts in the zooecia of the Paleozoic Trepostomata and in these alone. It is the purpose of this paper to carry through this comparison systematically.

II.—Stolons and Basal Plates

A.—Stolons of Modern Bryozoa

Entoprocta.—The colonies of the Entoprocta arise from creeping branching stolons or from modifications of such stolons.

The typical *Pedicellina* stolons consist of thread-like branching tubes, not unlike the stolons of plants, that creep over the substratum and are firmly attached to it by clasping plates, the "Haftplatte" of Ehlers.

In *Ascopodaria macropus* Ehlers a stolon often extends some distance from its origin without branching; then a center of branching occurs suggesting that the stolons in addition to giving off zooecium-bearing stalks were capable of establishing new colonies by asexual means (Fig. 1).

A single stolon arising from a branching center or from the base of a primary stalk may grow indefinitely in one general direction. Ehlers was unable to determine the length stolons attained in *Ascopodaria macropus,* being unable to separate one completely.[4]

According to Ehlers, stolons grow without any definite plan, but it seems to be the rule that stolons from one particular side of the original center have a more vigorous growth than the others. As we shall see later, this is characteristic of colony building in the Trepostomata, resulting from the plan established by the primary buds and inherited.

The stolons are tubes in the sense that they have walls differentiated from the embryonic tissue of their interiors; perforated dissepiments dip in from the walls to divide the stolons into segments. Each segment supports a zooid-bearing stalk. In the great majority of bryozoans, which bud directly without the intervention of stolons, the zooecia are in close contact, often amalgamated. The same condition would result in growths from stolons with short segments. We shall see that this is the case in the fossil Trepostomata. In the living *Pedicellinidae,* however, the zooecia are isolated.

The solitary *Loxosoma* is provided with what is known as a "foot gland," probably homologous with the "Haftplatte" of Ehlers. The "Haftplatte" is the organ that serves to hold a *Pedicellina* stolon to the substratum, organic or inorganic, living or dead, upon which a bryozoan may grow. The "Haftplatte" of *Pedicellina* is more highly elaborated than an ordinary base, as is also the "foot gland" of the Entoproct that, developing but one zooecium, has no place for a stolon.

Ectoprocta.—The primitive condition of budding from stolons is not limited to the Entroprocta; as typical stolons as any seen in the Pedicellinidae are to be found in the Ctenostomata, and modified stolons occur occasionally in all groups of bryozoans.

The earliest record we have of bryozoan life occurs in a fossil, *Heteronema*

[4] Ehlers, E. T. op. cit., p. 8.

priscum Bassler, from the lowest Ordovician rocks of Esthonia.[5] This is believed to consist of the fossil stolons of one of the Ctenostomata. Probably most, if not at all, of the fossils classed as Ctenostomata are stolons. The soft tissues that make up the Ctenostomata are not likely to be fossilized, but as we find among living Ctenostomata species in which the stolons burrow in shells, it is fair to presume that similar tracings in fossil shells were produced in the same way.

The stolons are not always buried. The freshwater genus *Pottsiella* has distinct stolons creeping over rocks, and even *Paludicella* branches suggest stolons.

The zooids in the Ctenostomata do not arise in the simple regular manner we find in the Entoprocta. In some a number of zooids occur on single joints. Of course, we know nothing of the character of the stalks and zooids that at one time were connected with the fossil stolons. Some of them may have belonged to the even more primitive Entoprocta.

In the Phylactolaemata, and probably in the marine Cheilostomata and Cyclostomata as well as the fossil Cryptostomata true stolons are absent, but they often have what Davenport called, in describing *Cristatella*, "a trasitional condition." It is this transitional condition of stolon formation that, in the Cryptostomata especially, has resulted in the formation of the many bizarre and often beautiful bryozoan colonies.

B.—Basal Plate of Urnatella

The zooecial stalks of *Urnatella* arise from an epitheca-like basal plate, called a disc. (Figs. 4 and 5). In young forms instead of a disc we see a simple stolon with two or three stalks arising at intervals as in *Pedicellina*. Davenport concludes: "The presence of a stolon in the young indicates a derivation from an ancestral condition possessing a stolon in the adult."[6]

The basal disc of *Urnatella* strongly suggests a coelenterate epitheca, but it is structurally and genetically a pseudo-epitheca made up of stolons. This is not easy to demonstrate in the average specimen. Davenport failed to find stolons in any of the old discs. He reached his conclusion, that the basal disc consisted of fused stolons, solely from his studies of the parthenogenetic reproduction in *Urnatella*.

Urnatella is found firmly attached to rocks or shells. In preparing specimens for microscopic study it is often of advantage to stain the colonies covering rock or shell in situ. This makes it easy to see the discs and determine the number of stalks to a colony. But for all that they are so plainly visible it is very difficult to separate untorn discs from the substratum. The torn fragments, however, often show clearly that the disc consists of a pavement of amalgamated stolons. I have seen a number of specimens which leave no room for doubt on this point.

Davenport records and figures two cases in which perforated dissepiments were observed between the stolon segments from which single stalks arose.

5 Bassler, R. S., The early Paleozoic Bryozoa of the Baltic Provinces, U. S. National Museum, Bull. 77, p. 57, 1911.

6 Davenport, C. B., op. cit., p. 27.

Suggestions of dissepiments are not infrequently seen even in old discs but here I have been unable to satisfy myself that they are perforated. The discs in which I have seen them also suggest that they may have been made up of fused stolons.

Epitheca-like basal plates consisting of amalgamated stolons occur, so far as I know, only in *Urnatella*. Among living forms it is unique in this respect.

There is a very decided difference in structure between the zooecial stalks and the stolons in *Urnatella*. The cuticula of the stalks occurs in two layers, on inner striated layer staining readily with haematoxylin and an outer layer of very simple structure. The stolons have a structure similar to the outer layer. A fragment of a stolon can always be distinguished from a fragment of a stalk.

C.—Pseudo-Epitheca of Trepostomata

The Trepostomata, when not attached to some foreign body, are often found with characteristic bases. These bases have been described by paleontologists as "epithecae." We read, for instance, of a bryozoan arising from a wrinkled "epitheca." The term "epitheca" should, however, have no place in the description of bryozoans; for these peculiar bases show a structure which is fundamentally different from the epitheca of Coelenterates, for which the term was proposed. Nor is it homologous with the peritheca, a calcareous layer formed by the edge-zones of corallites in a compound anthozoan.

The epitheca-like appearance is due to the under-surface of the base being wrinkled by fine lines crossed by coarser ones. The coarse lines do not break the continuity of the fine lines; they are simply undulations, giving, in a complete base, the appearance of concentric rings or waves. These waves may have been the result of periodicity in the activity of growth.

Monticulipora epidermata Ulrich and Bassler received its specific name from the distinctness of this arrangement. Specimens of this fossil are usually found as irregular masses partly attached to some foreign body that served as the support for the bryozoan colony. This support may have served only in the youth of the colony, for a free base may extend some distance beyond the distinct substratum of shell or other object to form a visible pseudo-epitheca marked by parallel, slightly curved lines, in reality delicate ridges. In the smaller discoidal colonies, free bases are often seen. They must have been but loosely attached, for it is not uncommon in many of these to find the structure of the base preserved in its entirety. It was in such specimens that Cumings noted the presence of a protoecium.[7]

A structure so delicate as the one we have been considering is easily lost in weathering and perhaps even before fossilization. When this occurs a free base will show the layer next above the fine lines. To the eye, this layer looks as if it were made up of lenticular cells.

Careful sectioning of suitable specimens shows that the so-called "epitheca" consists of a mass of closely packed stolons which run as thin threads parallel

[7] Cumings, E. R., Development of Fenestella, Am. Jour. Sci., vol. 20, p. 171, 1905.

to the surface on which it grew, each turning up eventually at right angles to the surface, giving rise to a zooecial tube. The lenticular cells which appear on the under side of a zoarium when this pseudo-epitheca has weathered away, represent the pattern formed by the intertwining stalks turning up, elbow-fashion, from the recumbent stolons from which they grow.[8]

Naturally it is in the *Monticuliporidae*, the most primitive of the Trepostomata, rather than in more advanced forms like the *Heterotrypidae*, that we find the most distinct stolons. These stolons are arranged in the form of basal plates, after the plan found in *Urnatella*. All families of the Trepostomata are inclined to follow this plan rather than the arrangement found in other *Pedicellinidae*.

A horizontal section of the visible pseudo-epitheca or a section passing between the base of a colony and the substratum will give a picture of a pavement of rectangular blocks. These blocks are arranged in parallel, slightly curved rows. (Fig. 6, 7.) They consist of amalgamated stolons, each divided into short segments by diaphragms. In fortunately situated sections the stolons can be seen arising from a more or less centrally located protoecium (Figs. 12, 14, 15). In some cases a single primary stolon arises to give off branches to form most of the base. This primary stolon has erroneously been considered an ancestrula.

In all instances this pavement of stolon segments becomes a spreading base of attachment such as is found in many of the Coelenterata. In one species, *Petigopora gregaria* Ulrich, this base even extends beyond the area from which the zoarial stalks arose. It is quite natural that it should have been considered an epitheca and that the Trepostomata were at one time classed with the Coelenterata.

Longitudinal sections, cut parallel to the zooecia, may intersect the stolons at right angles or may parallel them more or less, depending on the growth pattern of the basal plate. In the former case, the stolons appear as one or several layers of more or less rectangular or oval sections of tubes, above which rise the stalks or zooecia. (Figs. 9, 10, 17.)

The sections which parallel the stolons are the most instructive. In such sections individual stolons may be traced for varying distances with the zooecia springing from them curving from the prostrate into the upright position with sharp bends. (Figures 8, 11, 12.)

In their wall texture, the stolons of the Trepostomata differ as greatly from the stalks as do those of *Urnatella*. This is most distinct in the genus *Monticulipora*. Here a section of the wall of a stalk presents a striated appearance while the stolon wall seems practically without structure. The appearance of the stolons is so characteristic that they can be easily recognized whether seen in making up a pavement or singly where the section shows the

8 The base of the modern bryozoan *Schizoporella* presents a picture strikingly like that of a trepostome from which the stolons have been weathered. (Cumings, E. R., Development of some Paleozoic Bryozoa. Am. Jour. Sci., vol. 17, fig. 39, p. 57, 1904.) We see *Schizoporella* tubes just as they turn to become erect arising from each other. The trepostome gives the same picture for the lenticular cells at its base, which, in the absence of the stolons, seem to arise from each other, giving an erroneous interpretation of the structure.

edge of the pavement presenting the top and bottom walls of the stolon. A section vertical to the disc and passing through the center will always include more or less of the walls of a stolon. Cumings, in his studies of the development of the Trepostomata, aimed to obtain such sections; for so far as possible he used material in which the protoecium could be seen. His sections passing through it would naturally include a stolon radiating from it. He noted a peculiar wall structure that characterizes the protoecium and what he called the ancestrula and the primary buds. "It is clear and structureless with no evidence of fibres, laminae, or any of the characteristic features of the walls of ephebastic[9] zooecia." This peculiar wall structure is that of the stolons.

It is exceptional to find a vertical section in which a stolon can be traced any distance from the protoecium; consequently the wall structure that Cumings had noted as peculiar to the protoecium, the ancestrula, and the primary buds, cannot be seen in any single section beyond what he called primary buds. A number of sections is required to show that the structure peculiar to the central segments is actually peculiar to their continuations to the very edge of the basal plate.

The same may be said of horizontal sections prepared in uniform manner. The horizontal sections used in Cumings' studies were cut—as were the vertical ones—through the protoecium or at least near the level of the protoecium. Such a single section in itself is insufficient to give a correct interpretation of the bryozoan base, the pavement of stolons never being in one plane. The bases of discoid colonies tend to be concave, as, for instance, in *Prasopora conoidea* Ulrich or in *Mesotrypa patella* (Ulrich). Consequently a horizontal section passing through the beginnings of stolons surrounding the protoecium, as it approaches the edge, will gradually leave the basal stolons and cut through zoarial stalks at a higher and higher level. (Figs. 14, 15, 16.)

A colony may have one or more centers of growth. In the bases of discoidal discs, the single center of growth may be more or less centrally located (Fig. 14), or again it may lie near the edge of the disc (Fig. 16). Where there are several centers of growth, these may be, at least in some instances, connected as in the living Entoproct *Ascopodaria*, where a stolon gives off clusters of branches at intervals, each little cluster forming a subcolony. (Fig. 1).

Peronopora, after leaving the substratum, forms bifoliate fronds by folding in such a way that a frond has two layers of stolons attached to each other. (Fig. 9). A section cut in the plane of the stolons shows a pattern that differs in no way from that seen in sections of the basal plate. (Compare Figures 6 and 13).

Peronopora very commonly has an orthoceroid for a base. It is not unusual to see the base covered with a simple layer and at one side a bifoliate frond arising as if in growth around the orthoceras the two edges had met and continued as a bifoliate frond, with a layer of stolons between

[9] For the definition of this and associated terms, see Cumings, E. R., op. cit., 1904, (especially p. 66).

them. (Fig. 9, with crinoid stem joint as base). How some of the complicated folding occurs is not so clear.[10]

D.—Comments on the Stolons as Seen in Thin Sections

The study of fossil bryozoans requires the preparation and study of sections, and so long as our research is limited to the description of new species few difficulties are encountered. This is especially true of the Trepostomata; for in them as a rule but two preparations are required: a tangential one to show the shape and arrangement of the pores, mesopores and acanthopores, and a longitudinal section to show the internal structure and arrangement of diaphragms and cystiphragms. The surface to be used for a tangential section plainly shows the ends of the tubes; and since the bryozoan tends to split in the line of its zoarial tubes it is an easy matter to cut satisfactory longitudinal sections.

The conditions for obtaining sections of the fine lines that mark the pseudo-epitheca of a trepostome are not so simple. It has been noted that these lines are undulatory, and so, for all that they are largely parallel, a section will rarely present a long stretch of the structure they indicate.

At times the entire base is well preserved and free, but more often it is completely attached or presents but a partial free surface to serve as a guide for sectioning. When the entire bryozoan is attached, the creeping stolons are buried between the erect zoarial stalks and the irregular surface of the substratum. (Figs. 8, 9, 10, 11, 12, 17.)

It is difficult to prepare satisfactory sections under these conditions. Creeping *Diastoporidae* may confuse the picture, and an abundant and mysterious fauna of boring organisms—worms, sponges and what not—often take the place of the original base. This is so frequently the case that it seems probable that these organisms, parasitic or perhaps at times symbiotic, frequently aided in obliterating the pseudo-epitheca.

Whenever the pseudo-epitheca can be distinctly seen in a fossil it is a comparatively easy matter to cut sections demonstrating that the fine lines mark the position of tubes. But to show that the tubes are stolons requires the preparation of sections demonstrating the manner of their connection with the rest of the colony—and this is often difficult.

Cumings, in studying the development of Paleozoic bryozoans, devised a plan for cutting serial sections. He grinds a smooth surface. A photomicrograph is then made of this surface, handled, of course, as an opaque object. The surface is then ground down a definite distance and the process repeated. A number of illustrations of such sections, as many as needed, may be prepared and the series studied. Probably a better method would be to etch the surfaces and take nitro-cellulose impressions.

Serial sectioning, a method so useful to the biologist would, if it could be made to work for fossils, be ideal. But useful as the method of serial sections may be in biology, it is apt to prove deficient in paleontology. The biologists works with a living organism which he fixes, kills and orients to

10 Cumings offers a different explanation but sections do not seem to substantiate it.

assure obtaining sections in the proper direction throughout. The paleontologist cannot control the fixing and killing and for all he knows the structures at certain levels may have been greatly modified or destroyed in fossilization and consequently lost in the series of sections. In addition to this a distortion of the specimen too slight to be recognized externally might easily destroy the normal relationship of sections.

Gage, in discussing serial sections in general, says: "It is almost too easy, and with a lively imagination structural arrangements are described and depicted which never actually existed in the animals or embryos themselves."[11] If this occurs in the study of serial sections in properly oriented biological material, it is easy to see how serial sections, made in such a way that all portions of a given section may not be even of the same period of growth, could lead a paleontologist astray.

The study of many sections often makes it possible to recognize from what portion of the zoarium the section is obtained. Working with such knowledge is more apt to lead to correct conclusions than is implicit reliance on serial sections.

This is clearly shown in the genus *Monticulipora*. Here the difference in structure as depicted in sections passing through the stolons and those that pass through zoarial stalks in their early stages is very striking.

III.—Stalk and calyx: The Zooecium

A.—General Growth Habit of Urnatella

A colony of Urnatella, according to Leidy,[12] is made up of three, four, or even five stalks or zooecia arising from a common basal plate. (Fig. 5). Davenport records having seen only three with certainty. In specimens collected about Cincinnati, I have counted at least six positively and think that a larger number may arise. The colonies are usually found attached to the underside of heavy rocks in running water or in quieter waters on living or dead shells; indeed, they may be found attached to any object. Colonies are often found dead or in a dormant state, giving the appearance of a mass of close-set, minute, dark, stiff bristles covering the surface of a rock or shell. These stalks are never fused into compact masses as are the elements of the Trepostomata, nor for all that the stalks give off branches, is the budding ever extensive enough to form irregular masses or branches extending beyond the disc.

Colonies of the Trepostomata are often made up of similar flat roundish plates. In the majority, however, large numbers of stalks grow closely appressed, giving rise to zooecial patterns which look very different from the loosely constructed colonies of modern Entoprocts. Aside from the secondary effects of crowding, however, the individual zoecia exhibit the same structural features as those of modern Entoprocts, as will be seen presently.

In *Urnatella*, the stems are slightly flexible but not contractile. Leidy

11 Gage, O. H., The Microscope, p. 499, 1932.

12 Leidy, J., Urnatella gracilis, a fresh-water Polyzoan. Jour. Acad. Nat. Sci. Philadelphia, (2), vol. 9, 1884.

would have them bend to a considerable extent. This is true of young individuals; but according to my observations they are quite rigid except at the two ends.

I have often seen a colony or a group of colonies with stems erect and calyces expanded, a truly beautiful picture giving the appearance of a garden of Canterbury Bells; a slight disturbance, the tentacles retract and the calyces fall with the atrial opening down, then the stems bend at the disc and all fall flat in the same direction. The orientation of the different individuals of a colony is always identical. Indeed it seems that colonies of colonies may have the same orientation throughout. Ehlers has noted the same for the individuals of colonies of *Ascopodaria*.[13] It would seem that an intimate connection must exist between stalks, probably through the stolons. But this does not account for stalks of a number of colonies falling in the same direction.

Many of the Paleozoic bryozoans have a ball and socket joint connecting a plate made up of short, often modified stems with the trunk of an ordinary erect bryozoan colony. The socket consists of modified stolons which are derived from the stolons that go to make up the basal plate. The ball, which is really a point, consists of the immature region of the main trunk of an erect bryozoan. The point is the result of the free branching that rapidly thickens the trunk as it leaves the base. The mature region has the usual structure. No doubt considerable protection to the calyces would be afforded by the ability of such a colony to lie down flat on the sea bottom in times of danger.

This jointing is a common condition among the Cryptostomata. So far as I know in the Trepostomata it occurs only in *Lioclemella* and possibly in *Eridotrypa*.

B.—Stalk and Calyx in Urnathella and Pedicellina

Urnatella. Examined under a hand lens, the stalk of an *Urnatella* individual has a moniliform appearance with dark lines at the constrictions. (Figs. 4 and 5). The dark lines mark the location of diaphragms between segments in the interior of the stalk. Leidy counted as many as eighteen of these segments. I have never seen more than eight.

The bristle-like, segmented stalks of *Urnatella* found dead or in a dormant state end in shallow cups that have as firm a structure as the rest of the stalk. This is the condition in which such an organism would be fossilized. (Fig. 5).

The cup is actually a part of the zooid. When the zooid is destroyed by accident or otherwise, the firmer lower portion of its ectoderm is left as a shallow cup. According to Ehlers, a similar condition occurs at times in *Ascopodaria*. The general body of the living zooid is very much larger than the cup. There are no retractor muscles to draw the zooid into the zooecium, for zooid and zooecium are one.

13 Ehlers, E., Zur Kenntnis der Pedicellineen, Abh. Königl. Ges. d. Wiss. Göttingen, Phys. Pl., vol. 36, pp. 114-120, 1890.

When a calyx is replaced, after accidental loss, it is replaced by budding from the subadjacent segment. A direct regeneration of the calyx never occurs, for in budding the stalk is always formed before the calyx.

The stalk of *Urnatella,* thus, does not grow by building one segment upon the preceeding one, each in turn housing the living zooid, if indeed, this ever actually occurs anywhere in nature. The entire stalk grows, the transverse septa being formed secondarily. For the uniformly segmented stalk of *Urnatella* is not simply a support for the calyx: it contains structures of vital importance to the economy of the organism. It houses the excretory organs, musculature, and food-storing tissues.

Excretory organs may be found to some extent in the stalks of other Entoprocta. *Urnatella* is unique, however, in that each segment has a complete excretory system. This is in itself enough to establish its primitive position among bryozoans.

The muscles are found just within the ectoderm and extend throughout the entire stalk from base to calyx. (Fig. 3.)

Inside the musculature, the lumen of the segments is filled with a mass of tissue. This tissue consists of elongated cells and yolk-like globules. Davenport has shown that the yolk globules are derived from the intimately associated elongated cells.[14]

In dormant segments the mass of globules shrinks away from the walls of the segment. In such segments remains of the elongated cells are rarely seen, but occasionally even in the segments of old stalks, found late in autumn, in old dried-up stream beds, a few of the elongated cells persist. The protoplasm of segments of dried stalks retains, for a long time, a vitality on which depends the rejuvenation of a colony by budding after a period of dormancy.

The life history of *Urnatella* during the winter is not positively known. Probably Leidy is right when he says, "On the approach of winter, or under unfavorable circumstances, the polyp-bell of *Urnatella* dies and disappears. During the winter the matured segmented stems apparently continue alive and unchanged."

Leidy suggested that the segments of *Urnatella* served as statoblasts. This is undoubtedly true, but they are structurally in no way homologous with the statoblasts of other bryozoans. The statoblasts of the Phylactolaemata are highly specialized internal buds derived from the funiculus.[15]

In *Urnatella,* the budding that occurs from dormant segments is identical with that which occurs from the living segment. This will be taken up later.

"*Urnatella* is quite unique among Entoprocta in the storage of food material in its stalk"—so says Davenport. We can go farther and say that *Urnatella* is unique among all living bryozoans in having a stalk with reservoirs of dormant vitality. This may be a primitive condition lost in the

14 For a complete account of the anatomy of the stalk, see Davenport, C. B., op. cit., pp. 3-9.

15 The statoblasts of the fossil *Ceramoporidae* are probably homologous with those of the Phylactolaemata. It is possible that the Phylactolaemata have a very old ancestry. They also may be "living fossils."

more highly developed bryozoans. Leidy likened the segments of *Urnatella* to the proglottides of tape worms. There is no homology here, for all that the Platyhelminthes are probably closely related to the ancestors of *Urnatella.*

The "storage of food material" in the stalk of *Urnatella* may or may not be considered a primitive condition, but when such an important structure is found only in a single species of a single genus of a very small group of organisms, one can but feel that similar structures may have at some time been common and important to a much larger class. The implication is that the handful of living Entoprocta make up a relic group with *Urnatella* as its most characteristic "Dauerfossil."

Pedicellina. The individuals of *Pedicellina* form loose colonies that arise from meandering stolons. In contrast to *Urnatella* their stalks are simple tubes with practically no diaphragms. (Fig. 2). Externally, therefore, the stalks resemble the stolons. Aside from accessory features, such as spines and glands, the only difference is found in the number of diaphragms, the stolons having many, while the stalks have practically none.

In *Pedicellina,* thus, the stalk's main, if not sole function is that of support for the zooid. The very simplicity of this structure may be taken to indicate that the organism has evolved beyond the less differentiated stage in which the stalk shares the functions with the zooid, as it does in *Urnatella.*

The stalks of *Pedicellina* occasionally give off branches. When they do so, the branch is in every way identical with the original stalk (Fig. 2). Here, as in *Urnatella,* there is no good evidence that when a calyx is rejuvenated, the stalk is lengthened by the envelope of the old calyx, for all that occasional diaphragms occur in the stalks of all species of *Pedicellina.* Stalk and calyx live and grow as specific entities.

Other Genera.—The genus *Arthropodaria* was created by Ehlers for one species which in a sense stands intermediate between *Pedicellina* and *Urnatella: Pedicellina bedeni* Föttinger. In it the stalk is segmented by perforated diaphragms, without exhibiting otherwise in its anatomy the undifferentiated condition of Urnatella.[16]

In other forms, such as *Pedicellina belgica* v. Beneden and *Pedicellina nodosa* (Lomas), which Ehlers assigns to the genera *Ascopodaria* and *Gonypodaria* respectively, there is, according to Davenport, "a poorly expressed and highly variable segmented condition."[17] The existence of such intermediate forms is of considerable interest.

C.—The Zooecium of the Trepostomata

The zooecia of the Trepostomata consist of long cylindrical tubes with terminal orifices. The tubes grow in crowded colonies and from this crowding often, especially in their proximal portions, assume prismatic shapes. The more distal portions have thickened walls with a complicated structure which tends to give the tubes irregularly round openings. This changing character of the tubes as they develop has given the name (*trepos,* change) to the order.

16 Ehlers, E., op. cit., p. 144. (Ehlers calls the unsegmented stalks "phalangae," the segmented ones "phalangaria").

17 Davenport, C. B., up. cit. p. 19.

The proximal portion of the tube is known as the "immature" region, the distal as the "mature" region, as if the second developed from the first. For all that these terms are so forced, long usage has made them almost indispensable.

The "immature" tubes arise from stolons and are capped by one or more segments forming the mature region. Aside from the complications which arise from the crowding, the tubes may be interpreted as the exact counterparts of the stalks in the *Pedicellinidae*. In a few genera, such as *Anaphragma*, the zooecia have no, or almost no, diaphragms. They correspond directly to the stalks of *Pedicellina* which differ from the stolons by their unsegmented condition.

In the majority of the more highly developed Trepostomata, especially in the *Heterotrypidae*, the immature region bears diaphragms, as do the stalks of *Arthropodaria*, differing from the stolons merely in the upright position and in the smaller number of diaphragms. The walls of the immature region are so thin that, if they stood singly, they would not support a polypide. It is probable that the crowding, which imposes a prismatic shape on the zooecia, also is responsible for the reduction in the thickness of the walls.

The mature region of the Trepostomata is made up of segments with thickened walls. As a rule, there are also more diaphragms than in the immature regions, and accessory parts are present. The last open segment forms the cup.

If the cups at the ends of the tubes in the Trepostomata are homologous, as I believe they are, with the cups of *Urnatella* and *Pedicellina*, they must have supported rather than housed their soft zooids. This seems probable when we remember that the cups in many Trepostomata are very shallow. Wherever the cups are deep they are surrounded by other structures such as acanthopores. It may be that in some instances the cup partially housed the zooid and protected it by acanthopores or secondarily thickened walls. It must be remembered that, if we are justified in assigning the Trepostomata to the Entoprocta, many of them represented highly evolved Entoprocta, while *Urnatella* is a primitive form.

The undifferentiated condition of *Urnatella* is found among the Trepostomata in *Monticulipora*. In this genus no difference between an immature and mature region exists. The zooecium is made up of undifferentiated segments homologous with those of the stalk of *Urnatella*. It seems reasonable to assume that in *Monticulipora* the segments contained the primitive vital organs we find in the segments of *Urnatella*. It is significant also that throughout the whole length of a zooecium peculiar curved structures occur in *Monticulipora*, known as cystiphragms. They will be discussed later in detail. The analogy with *Urnatella* suggests that they were connected with the storage of food material.

The cystiphragms which in *Monticulipora* exist throughout the zooecium, are limited in other Trepostomata to the mature region. The assumption seems justified, then, that the mature region of the Trepostomata, like the whole zooecium of *Monticulipora*, is homologous with the stalk of *Urnatella*,

representing an essential organ of the animal, housing vital organs and tissues and stored food materials.

The presence among the Trepostomata of both, differentiated and undifferentiated, zooecia, corresponding to the extremes of *Pedicellina* and *Urnatella* respectively, with a wide range of intermediate forms is a strong argument in favor of the correctness of the views set forth in this paper. This is strengthened by the presence of a basal plate showing its origin from amalgamated stolons, in the modern as well as the fossil example of the undifferentiated type.

Just as the stalks of *Pedicellina* give off occasionally branches which grow in every way identical with the mother stalk, so the immature region of the Trepostomata gives off branches which develop as definite a mature region as do the stalks that arise directly from the stolons. The manner of budding in general will be taken up later.

IV.—Significant Structural Details of Stalk and Calyx

A.—Perforated Diaphragms

The Most Distal Diaphragm. The floor of the cup forms the most distal septum of the segmented stalk of *Urnatella.*

"The most distal septum, which separates stalk and calyx, is more complicated than the others. The complication is due to the fact that mesenchymatous cells have placed themselves in and above the opening of the septum, and have flattened themselves out perpendicularly to the axis of the stalk, while still allowing the vacuolated cells to pass at their margins into the calyx from the stalk. Thus the transversely flattened mesenchymatous cells appear to send out horizontal processes between the tubular cells." "Such a highly complicated septum seems indeed to be common to all the Pedicellinidae, which in this respect appear more nearly allied to Urnatella than does Loxosoma in which such septa are absent."[18]

It does not seem likely that such a delicate structure could be preserved in fossilization. But the fact remains that the perforated plate or septum at the base of the very shallow cup of the trepostome *Hallopora* is a complicated structure often highly ornamented.

Bassler and Ulrich both considered these plates to be covers for the zooid. Bassler[19] describes them as follows—"Apertures closed in the perfect state by perforated, often ornamented, covers, which are left behind, as growth proceeds, to form floors (diaphragms) of succeeding layers." Ulrich[20] expresses the same view.

If the perforated plate of *Hallopora* formed a cover for the zooid and

18 Davenport, C. B., op. cit., pp. 8-9.

19 Bassler, R. S., in Zittel, "Text-book of Paleontology," 2nd edition, edited by C. R. Eastman, p. 337, 1913.

20 Ulrich, E. O., Chapter on Paleozoic bryozoa in Geological Survey of Illinois, vol. 8, p. 315, 1890. Here also good illustrations in figure 5, p. 315.

later a diaphragm, the zooid must have grown or budded through the perforation and lived on top of the plate there building itself a new roof using the old one for a floor. Rather a strange performance even for a fossil! The *modus operandi* of building what Leidy called "a new head on old shoulders" in *Urnatella* will be discussed later.

The perforated distal diaphragms of the Trepostomata are in no way analogous to the opercula of the Cheilostomata or the setae of the Ctenostomata, nor to the facets or post mortem perforated lamellae of the Cyclostomata.

Urnatella and other species of the *Pedicellinidae* are, so far as I can learn, the only living bryozoans in which the zooid is separated from the stalk by a perforated diaphragm.[21]

Normal diaphragms. The stalk of *Urnatella* is divided into compartments throughout its entire length. These compartments are separated by perforated diaphragms lacking, however, the elaboration of the distal one. The perforations are often closed by a thin layer of cuticle.[22] In specimens found dead it is often difficult to see the opening in the diaphragm. It is probable, however, that a free communication extended throughout the living stalk.

Perforated diaphragms have been observed in a number of Trepostomata. In *Anisotrypa fistulosa* Ulrich, the perforated diaphragms occur, regularly spaced, throughout the whole length of each tube or stalk. The amalgamated tubes or stalks arise from a wrinkled epitheca, analogous to the disc of *Urnatella,* and only the proximal segments are thin walled and suggest an immature region.

In other species of *Anisotrypa* and in *Stenopora* the same perforated diaphragms prevail, but the immature region is more highly developed. The *Urnatella*-like diaphragms do not appear in *Esthoniopora* and *Hemiphragma,* but the free communication is there. *Anaphragma* has no, or almost no, diaphragms.

In the majority of Trepostomata, however, the diaphragms are not perforated; they are often so crowded as to make their significance very uncertain. They surely did not house successive zooids. Whether communication between the segments existed or not can not be determined.

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21 The polyp of the hydrozoan *Obelia* rests on a perforated plate which separates it from the stem. *Obelia* goes even farther in an evolution paralleling the Trepostomata, for its stems present a structure quite analogous to that of the mature regions of the Trepostomata. If the Trepostomata were not Entoprocta, they may have been Coelenterata!

22 Histologically, the stalk of *Urnatella* consists of a thick cuticle marked externally by depressions corresponding to the location of the diaphragms and by scars of lost branches. Davenport has shown that the cuticle is made up of two layers; within the cuticle lies the ectoderm. A circular fold of ectoderm surrounding a small opening makes the inner layer of each diaphragm. A perforated disc of cuticle, continuous with the superficial cuticula, projects into and between the layers of ectoderm strengthening the diaphragm. This becomes thicker with age.

B.—Wall Glands, Spines, and Acanthopores

The stalks and never the stolons, in most of the *Pedicillinidae,* have glandular walls. The glands are found in various conditions of development. Ehlers presents a good account of this structure.

"A formation appears in the outer wall *(Haut)* of the stalks *(Träger)* which is independent of the development of the muscle layer. It reaches its highest degree of development in *P. echinata* (S.) and shows itself here in spines which cover the entire surface of the stalks. A group of cells very similar to those which I described as lying beneath the stalk pores of *Ascopodaria macropus* lies beneath each of these spines. The axis of every spine is filled by a projection from one of these cells. Whether the tip of the spine is pierced or not, I cannot say with certainty.

"The stalk pores heretofore elaborately described, I consider genetically closely related to the spines of *P. echinata.* That the latter stand on soft cuticula while the pores occur only on firm walls does not affect the validity of the suggested homology. It is possible that the reduced condition of the pores, compared with the spines, can be attributed to the difference in the stretches of walls on which they grew. But I do not wish to express an opinion, for the soft-tissued stalks of *P. glabra,* which is otherwise so closely related to *P. echinata,* possess neither spines nor any trace of wall pores."[23]

I have quoted the passage from Ehlers in full for it presents, without any intention on the part of the author, who simply described what he saw with no theoretical questions in mind, a remarkable description of a relic organ. We have in the *Pedicellinidae* a small group of primitive bryozoans. In about half of the species poorly developed wall glands appear, in one species these glands become definite, prominent spines, (Fig. 2), while in the species most closely related neither glands nor spines are to be found.

Among the fossil bryozoans the Trepostomata, which arise from stolons as do the living *Pedicellinidae,* are unique in the presence in many genera of peculiar spines known as acanthopores. In many species they are most elaborately developed; indeed the picture they at times present suggests the bizarre ornamentation one often finds to characterize the decadence of a group of organisms.

The acanthopores consist of hollow tubes as do the spines of *Pedicellina* which are connected with a wall gland.

In the Trepostomata, as a rule, the acanthopores continue beyond the stalk and parallel with it. In *Pedicellina* the spines are set at right angles; but as the stalks or tubes of the Trepostomata are amalgamated, no other arrangement would be possible.

The acanthopores of the Trepostomata are never found in the stolons. As a rule they are most prominent at the distal end of stalks, but longitudinal sections will often show them deep down in the bryozoan mass. Acanthopores are often found at the beginnings of stalks; indeed in species described as having no acanthopores, they are often found there. Cumings has described them in *Rhombotrypa* bases, and it has been my fortune to

23 Translated freely from Ehlers, E., op. cit., p. 48.

find them in other supposedly acanthopore-free species. It would seem that in such cases the spines existed only in the young stages of growth.

Urnatella, for our speculations the most important of the Pedicellinidae, has aborted wall glands on the calyx and on the segments of the stalk. *Monticulipora molesta,* of all Trepostomata closest in structure to *Urnatella,* has no true acanthopores, but the wall structure suggests the presence of aborted acanthopores.

If we consider *Urnatella* as a relic of primitive Entoprocta incapable of secreting lime, its wall glands suggest that some of the class from which it evolved had spines,[24] just as some species of *Pedicellina* are provided with spines and some are not.

C.—Vital Tissues of the Stalk, Cysts, and Cystiphragms

The correlation of the histological structures of fossil with living organisms is often very uncertain. The best conclusions are reached only in a general way. We find walls of fossil organisms made up of different layers, but we are not prepared to say positively that these layers correspond to seemingly similar layers in the living. It is only when a strong suggestion of function is combined with the structure that we reach conclusions, and even these are often purely tentative. And this becomes doubly difficult when we compare a large class that has through coenogenesis developed a great variety of forms, with a very small group of living organisms which represent, perhaps, only the more primitive of the fossil group.

We must not expect to find in each member of a diversified fossil group the structures of the living fossil. All we can hope for is to find here and there in different members of the fossil group structures identical with, or structures whose implied function would be identical with, that of the living.

The cup supporting the zooid and the perforated diaphragms we have considered identical with similar structures in certain of the Trepostomata. That perforated diaphragms are absent in many of the Trepostomata does not invalidate the idea that the Trepostomata were Entoprocta any more than their absence in *Loxosoma* excludes this genus from the living Entoprocta.

The internal structure of the segments of *Urnatella* beneath the cup could hardly be preserved in fossilization. They consist of muscles and excretory organs and finally of the elongated cells from which reserves of food material for future budding are derived.

In many of the Trepostomata segments occur with a highly complicated structure, the "cysts" and "cystiphragms," associated with masses of iron salts that could well have been derived from organic matter. On a previous page, the conclusion was drawn that wherever this complicated structure appears in definitely limited segments, it is permissible to consider the trepostomate segments analogous in function to those of *Urnatella.*

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24 The structures peculiar to the Cheilostomata, the vibraculae and avicularіae, are highly differentiated zooids. It has been suggested that the acanthopores of the Trepostomata are homologous with these, but the acanthopores are too definitely portions of zoarial walls to be considered modified zooids.

The structure of the zooecia of this type is unique among bryozoans. It consists of curved plates (cystiphragms), attached in one or many rows to the inner walls of the tubes. Curved diaphragms and infundibular diaphragms are probably homologous structures. Very delicate cysts with openings like bottle necks inclose the masses of iron salts when these are present.

These structures vary greatly in number, and in some members of this greatly diversified group they seem to be entirely absent. In others they practically take the place of diaphragms, making the entire stalk, after it leaves the supporting immature region, consist of a single segment with a complicated internal structure. Their constancy in different genera and species has made them useful as a basis for classification.

We must abandon all thought of an organism which superimposes one zooecium upon another as it grows when we find that its proximal segments have highly differentiated structures that suggest functions other than those of the zooid.

In Trepostomata, as in *Urnatella*, the most distal segment is a simple affair, while the other segments have complicated structures. Cumings and Galloway state that "in functional zooecia"—for example in the surface layer of zooecia—"cystiphragms are often absent or restricted."[25]

I believe the cystiphragms are never found in the most distal segment, i. e., the cup. They are not developed as Cumings and Galloway claim, "somewhat late in the life of the polypide," if by "polypide" we mean the active zooid at the end of the stalk. According to the interpretation offered here, the segments of the mature region were, as the segments of *Urnatella* are, essentially part of the living organism. If this is the case, cystiphragms and their allied structures are not for the purpose, as has been suggested, of strengthening the zooecial walls or enclosing dead zooids represented by the masses of iron salts.

Cumings and Galloway, in the very important paper mentioned above were the first to note in the segments of tubes of the Trepostomata masses of iron salts which they concluded were the fossil remains of organic matter. These masses must have been noticed by earlier students, they are so plain and abundant. But to Cumings and Galloway belongs the credit of pointing out their importance in the economy of the organism.

The conclusion reached is best stated in their own words: "Taking into consideration, therefore, the size, relations to surrounding structures, nature of the material, and its isolation, there can be no doubt that the brown material is due to the replacement, probably by iron sulphide or iron sulphate, of organic matter left after the death of the polypide."[26]

The authors then offer alternative explanations. One is that these brown masses are homologous with the *"brown bodies"* of recent bryozoans (*Cheilostomata*), which arise through the degeneration of joints. Another is that

25 Cumings, E. R. and Galloway, J. J., Studies on the morphology and histology of the Trepostomata or Monticuliporoids, Bull. Geol. Soc. America, vol. 26, pp.349-374, pls. 10-15, 1915. (Quotation from p. 354).

26 Op. cit., p. 353.

the brown masses may be pathologic. The idea that the brown masses are fossilized "brown bodies" is extensively discussed and properly rejected.[27]

The intimate association of the brown masses with cysts and cystiphragms led Cumings and Galloway to suggest a causative relationship; that the brown masses had something to do with the origin or at least growth of cystiphragms. This is probably true, but not in the way they suggested.

I interpret these brown masses as the fossilized remains of dormant protoplasm homologous with the "food material" in the stalks of *Urnatella*. Of course, the brown masses are frequently absent. Indifferent protoplasm is not easily fossilized. But when they are present, they occur under conditions which distinctly favor this interpretation, as will be shown.

Ulrich, with his usual perspicacity, suggested that cystiphragms might represent ovicells. The segments would then play a rôle much the same as that here suggested.

One very important statement with regard to the brown masses is found in Cumings and Galloway's description: "They are often found in numbers just beneath an overgrowth." The term overgrowth suggests an abnormality, while in reality the feature to which it refers represents a normal process of rejuvenation. It may come into existence as the result of a normal periodicity of growth, or as resumption of growth after an accidental interruption.

Many Trepostomata had a periodicity in growth. This can readily be seen with the naked eye in any of the more massive forms such as *Amplexopora filiasa* (D'Orbigny) or massive species of *Homotrypella*, etc., where the line between periods is very distinct. Beneath each line the brown masses are often so abundant as to run a distinct streak across the section. This periodicity does not destroy the general symmetry of the mass (Fig. 17). The colony stopped growing and after a dormant period started again, retaining its general shape.

The last growth period of such a composite colony ends with tubes that have reached maturity. The surface of the mass is found covered with cups surrounded by acanthopores. Beneath the surface, the tubes bear numerous diaphragms. In some species cystiphragms abound and occasionally the brown masses are in evidence.

The picture is different where an earlier period of growth is topped with a new growth after an accidental interruption. In that case we find only the lower portion of the mature regions preserved. Diaphragms, cystiphragms, and brown masses are present in abundance, but the cups and acanthopores of the earlier surface are missing. Evidently the old portion lay long dormant without active zooids, having even lost the segments that supported them. All that was left were the lower segments of the mature region, often filled with masses of iron salts surrounded by cystiphragms.

The new growth starts with recumbent tubes that quickly straighten. The recumbent portion of each tube, including the bend where it straightens, is often made up of but one segment of the immature region. At times a

27 Op. cit., pp. 353-356. In the "Summary and Conclusions," however, the authors speak of "successive degenerations and regenerations." Apparently they did not quite get rid of the "brown body" idea.

suggestion of a basal plate such as that formed by the stolons of *Urnatella* is seen (Fig. 17). The immature region may be very short, even shorter than the mature region topping it, or it may be quite long. This probably depends upon the environment.

From this I conclude that new growths arose from the dormant segments of the Trepostomata in the same way that they arise from the dormant segments of *Urnatella*, namely by budding from dormant segments of the stalk. Sections at times will even give a picture suggesting a brown mass flowing from a dormant cell into the new growth.[28]

In the Trepostomata, as in *Urnatella*, the stalks did not grow by forming segments serially. A stalk of some length could be formed before it became divided by diaphragms. The accumulation of masses of "food material" may have been the determining factor in diaphragm and cystiphragm building, either supporting or limiting them.

The Trepostomata are far from being unique among bryozoans in showing periodicity of growth. In the Trepostomata-like *Heteroporidae*, superposition of subcolonies occurs. In *Multicresis pulchella* "the exterior lamella has its origin in a tube of an internal lamella; the tubes and the mesopores are very much shorter, but they have the same characters as the tubes of the internal lamella." In *Ceriopora*, zonal lines occur which Canu and Bassler have interpreted as "arrests of growth occasioned by the seasons."

In none of these is there evidence of a long dormant period between growth such as is suggested in the Trepostomata, where the new growth starts from broken or worn tubes. The uniformity of structure in the tubes throughout a colony of any one of the Heteroporidae would, however, make it almost impossible to recognize broken or worn tube ends were they present.

Suggestion of a reserve "food material" in connection with an overgrowth is never, so far as I know, found in any of the Cyclostomata.

V.—Embryological Development and Zoarial Growth

A.—Protoecium and Ancestrula

Comparatively little had been done to solve the problem of these Paleozoic bryozoans prior to the notable work of Cumings in which he attempted by a study of the budding order of the initial growth stages of the bryozoan colony to establish the systematic position of the Trepostomata.[29]

In this work he rendered a distinct service to biology and especially to paleobiology by emphasizing the importance of a study of the development of colonies, of what he calls phylembryology, to take the place of embryology, so necessary in phyletics. From the very nature of an embryo, embryology

28 In *Urnatella*, there is no true periodicity of growth, the dormant segment becoming detached when the new growth is established.

29 Cumings, E. R., Development of some Paleozoic Bryozoa. Am. Jour. Sci., vol. 17, pp. 49-78, 1904.

as an aid to systematic classification is denied the paleontologist. But when we deal with colonial fossils, the often definitely recorded budding order may take its place. Such studies are particularly adaptable to bryozoans, for here a stage, often calcareous and capable of fossilization, exists that is intermediate between the free larval life and the adult life, that of the protoecium. For a proper appreciation of the results of these studies, it is necessary to go somewhat into the details of the ontogeny of modern bryozoans.

The ontogenetic development of the Entoprocta and Ectoprocta is entirely homologous, although this is not evident at first sight. Both groups pass through a planctonic larval stage and become attached before their larval development has been completed. The Entoprocta become attached comparatively early in life and pass through a large part of their metamorphosis after fixation. In the Ectoprocta, on the other hand, much of the metamorphosis takes place within the mother animal.

At the end of its free life, the larva of an Entoproct becomes fixed by the blastoporic pole, that of an Ectoproct by the opposite pole. In the Entoprocta, the completion of growth involves a rotation of mouth and anus. In the Ectoprocta, the larval organs degenerate to form a mass known as the "brown body," to which reference was made on an earlier page. Regeneration forms the true alimentary canal, and the lophophore makes its appearance. This stage ends with the formation of an exoskeleton, the protoecium, and with the primary budding. In both, the Entoprocta and the Ectoprocta, the first budding takes place at the blastoporic pole; that is, in the Entoprocta at the base of the protoecium, in the Ectoprocta at the other, the distal end.

At the protoecium stage, the animal of the Entoproct does not differ materially from the later mature individuals of the growing colony. In the Ectoprocta, on the other hand, the animal that occupies the protoecium is still far from maturity. The lophophore is poorly developed and not completely retractile. In the Gymnolaemata the posterior tentacles have not moved inward to complete a circle. In the Phylactolaemata the two anterior processes of the lophophore arm have not yet come to unite just behind the epistome. In fact, at this early stage of the development of an Ectoproct, it would be difficult to say whether the anus opened without or within the crown of tentacles.[30] The zooid living in the protoecium may be an entoproct in reality or the entoproct stage in the ontogeny of an Ectoproct.

This difference in the relative advancement of the zooid, which occupies the protoecium, explains the different rôles the protoecium plays in the Entoprocta and the Ectoprocta. In the former the protoecium can be recognized in the fully developed colony as the unit from which the stolons, and with them the colony, take their start. In other words, the protoecium sufficed to house a zooid sufficiently mature to form the parent individual of the colony.

On the other hand, one could hardly expect the protoecium that sufficed

30 In a way this is an idealized picture; so much of the larval life of the Ectoprocta goes on within the parent that some forms may have no protoecium stage, while in others the zooid is more advanced than the one just described.

to house the primary individual of a simple entoproct with its undeveloped, hardly retractile lophophore to furnish protection for a fully grown entoproct bryozoan with a lophophore that carries its crown of tentacles far beyond the mouth of the zooecium and at the least danger retracts and hides them. Correspondingly, a larger zooecium arises from the protoecium of the Ectoprocta, the ancestrula, which houses the first fully-grown zooid. The colony is then developed by budding from this ancestrula and not from the protoecium as in the Entoprocta. In other words, while the Entoprocta stop at an early stage of house building, the more elaborated Ectoprocta go on to another stage before the budding is begun which leads to the building of a zoarium.

Both, the protoecium and the ancestrula, are capable of fossilization as they are often calcareous. Thus Cumings was able to compare the beginnings of colonial growth in the Cyclostomata and in *Fenestella*,[31] a genus of the Cryptostomata. The protoecium of *Fenestella* is homologous with the basal disc of the Cyclostomata, and the ancestrula with the primary zooecium of the Cyclostomata. The primary buds which arise from it develop into long, tubular zooecia like those of the Cyclostomata, still lacking the long vestibule and hemisepta which characterize the mature region of the Cryptostomata.

This, then, is a fossil example of the general relation which had been brought out by the researches of Nitsche, Pergens, and others, "that the early budding habit frequently differs considerably from the later or normal habit of the colony, and more resembles that of the ancestral type," a striking illustration of the fundamental law of biogenesis.

B.—Primary Stolons

The case in which primitive zooecia arise from the first fully formed zooecium, Davenport considered as transitional between the most advanced case of Ectoproct colonial growth and the primitive condition which exists in the Entoprocta, where budding of the protoecium produces stolons.

Davenport understands "a stolon in its morphological sense to signify a mass of embryonic cells derived from a parent individual and capable of reproducing non-sexually one or more daughter individuals at some distance from that parent." This interposition of a stolon between the primary zooecium and the buds that form zooid-bearing stalks is probably a very primitive condition. The stolons are formed from an excess of embryonic tissue and are thus analogous to coenenchymal budding in the Coelenterates. It is, in fact, the nearest approach to it among bryozoans. For in the rare cases in which a vesicular, coenenchyma-like tissue is formed at the bases or between the tubes of bryozoans, it never produces buds as it does on the Coelenterata. On the other hand, coenenchymal budding is actually replaced by the formation of stolons in some of the Coelenterata.

The first stolon arises from the blastoporic pole which is the point by which the entoproct larva becomes attached. Consequently the primary buds arise from the base of the protoecium, the base of the first complete indivi-

31 Cumings, E. R., Development of Fenestella. Am. Jour. Sci., vol. 20, pp. 169-177, 1905.

dual of the colony. More than one stolon may arise, but probably not at the same time. The stolons may branch soon after arising but often first grow to some length. The general similarity of the habit of zoarial growth in the primitive Trepostomata with that of the early budding habit of the Cyclostomata and Cryptostomata caused the stolons in the former to be overlooked. Cumings' descriptions of the ancestrula in *Prasopora* is actually a good description of the first stolon with zooecial stalks in *Monticulipora*. "Diaphragms and cystiphrams make their appearance very near the point of origin of the ancestrula. It is evident that in the case of the Trepostomata only the lower portion of the long tabulated tube, seen in the figures, can represent the true ancestrula, since this tube was undoubtedly occupied by a succession of superimposed buds. In this feature consists, *par excelence*, the prime characteristic of the Trepostomata." And then to settle the matter we read: "No definite plane of demarcation between the ancestrula and the protoecium exists in the Trepostomata, such as is to be seen in Fenestella and the Cyclostomata."

We can emend the last statement to read: *No ancestrula exists in the Trepostomata.* Instead, stolons are interposed between the protoecium and the individual zooecia of the colony. The primitive nature of this growth habit points to a primitive anatomy of the animal that displayed it, one that must have allied it more closely with the most primitive of the living forms of bryozoans, the Entoprocta, than with any other group.

C.—Vital and Abortive Branches and Secondary Stolons

The production of stolons is not limited, however, to budding from the protoecium. In *Urnatella* as well as in the Trepostomata, they are produced from the stalks as one product of budding.

Urnatella.—On actively growing stalks of *Urnatella,* buds make their appearance shortly after the formation of a diaphragm and immediately above it; that is, they always arise from the lower part of the segment (Fig. 3). They never arise from the calyx, but are always found near the tip, i. e., in the last segments, where growth is active. With the exception of the most proximal segment, the lower segments form no new buds, but they are marked with scars of buds formed in their youth. As a rule the buds form branches that fall from the stalk. Buds from the most proximal segment, however, often persist and form branches in every way identical with the parent stalk (Fig. 4).

The continually falling branches formed from buds developing from segments above the most proximal one are of two kinds, abortive branches and what Davenport calls stolons.

The abortive branches are made up of a series of segments topped with a calyx. They apparently die when separated from the parent stalk. The stolons usually consist of but one segment. On them several calyces arise always on that side which faces the distal end of the parent stalk. The under side of the stolon has a sticky surface that, after the stolon separates from the mother branch, becomes attached to some foreign body to form the disc of a new colony.

Leidy had suggested that the branches separating from the *Urnatella* stalk formed new colonies; but it remained for Davenport to show that two kinds of branches were formed and that only the stolons were capable of forming new growths. I have given this matter a great deal of attention in the study of many colonies of *Urnatella* collected about Cincinnati and am convinced that Davenport is right.

All of the distinct stolons of *Urnatella* that I have seen were in young colonies derived by budding from the distal segments of stalks. It is quite likely that many colonies develop from sexually produced primary stalks, but there seems to be no way of recognizing them, — and the aquarium has proved a failure. I have never succeeded in growing such colonies, nor have I ever found sexually mature individuals. Davenport reports finding only mature males. It is fair to assume, however, that development in *Urnatella* is identical with that of *Pedicellina* and that stolons can form sexually. I know nothing of asexually produced stolons in *Pedicellina*, if indeed there are any. In *Urnatella*, on the other hand, stolons budding from the stalks are of great importance to the species.

Trepostomata. In view of the other homologies, it is not surprising to find that all three types of budding that occur in *Urnatella* have their counterparts in the Trepostomata.

The permanent buds from the most proximal segments in *Urnatella* stalks correspond to the zooecial tubes in Trepostomata which branch from the immature region. They grow to maturity and cannot be distinguished in any way from the zooecia that arise directly from the basal plate.

The abortive branches of *Urnatella* have their equivalents in the mesopores of the Trepostomata. Like the former they arise from the distal, mature region of the essential zooecia. They are usually much smaller and have much more numerous diaphragms. It is significant that the brown masses of Cumings and Galloway are never found in mesopores. In view of the interpretation given here, this means that the mesopores did not store food material and did not, therefore, play the vital rôle of the essential stalks.

Gregory defined mesopores as "aborted zooecia" and later as "rudimentary zooecia." The first term is the more appropriate one if they are to be considered homologous with the abortive branches of Urnatella. *Urnatella* continually loses its abortive branches. A colony of close set stalks practically amalgamated, such as we find in the Trepostomata, could not lose them.

Finally, structures equivalent to the stolons that grow from the distal segments of *Urnatella* stalks are found throughout the zoaria of many Treposotomata, especially of ramose species, as bases of rejuvenation or overgrowths. The stolons that formed such bases of rejuvenation were undoubtedly of parthenogenetic origin as are the stolons arising from the distal segments of *Urnatella*. In the loosely disposed stalks of the *Urnatella* colony, the stolons drop off to form new colonies, but in the compactly united stalks of the Trepostomata they naturally remained attached and formed overgrowths.

In *Urnatella*, the stolons are grouped on the oral side of the main stalk. They in turn give rise to stalks bearing calyces which have their oral sides directed away from the mother stalk. A new colony formed from a single

stolon would be made up of stalks with the oral sides all directed in the same way. The stalks of an overgrowth have this arrangement as shown in sections, and so we may conclude that if the calyces had been preserved they would be found with their oral sides directed away from the center.

In *Monticulipora,* the stolons are especially noticeable. In that genus, as was described earlier in this paper, the stalk is not differentiated into an immature and a mature region. The characteristic wall structure and the cysts and cystiphragms are present throughout the zooecia, from their origin at the stolons of the basal plate upwards. For this reason the presence of stolons at the base of an overgrowth within a colony is easily recognized. In sections they appear as tubes without cystiphragms in the midst of the typical zooecia. They are not isolated, exceptional cases of tubes devoid of cystiphragms. They constitute groups of segmented tubes arranged to form pavements like those at the beginnings of colonies. In most cases such pavements are not easily recognized in longitudinal sections, for they are the bases of new growths that continue the direction of the original tubes (Fig. 17). Consequently they appear largely in cross sections at the origin of a rejuvenation.

The fronds of *Monticulipora molesta* are often arranged after a peculiar triangular pattern, the result of a growth to one side of the original frond. Where this occurs the overgrowth is seen with the stolons resuming the direction of the tubes from which they spring, suggesting an immature region without cystiphragms but not at its normal situation.

VI.—Conclusion

The history of life on the earth presents many instances of the sudden appearance of large biological groups. Often their disappearance was as mysterious as their appearance. One of the problems of paleobiology is to account for the origin and decline of such groups, and another to learn of their descendants, if they had any, and what they achieved in development.

The Trepostomata were such a group. They undoubtedly arose from forms incapable of fossilization. Through coenogenesis they developed a diversity of form far beyond that exhibited by their ancestors, but still retained the essentials of their group. The highly differentiated members ended in a racial decline leading to extinction. Those not so highly differentiated, still racially young enough to have a vitality capable of inducing new departures, probably started the evolution of the Gymnolaemata.

The Ctenostomata, the Cyclostomata, and the Cryptostomata appeared in the Paleozoic but did not reach full racial development until much later. Little is known of fossil Ctenostomata, for they could not be well preserved; eleven families exist today. The Cyclostomata reached their zenith in the Mesozoic but at the present time seem to be going down. The Cryptostomata were the Paleozoic representatives of the Cheilostomata, the dominant bryozoans of the Mesozoic and the present.

The Trepostomata have heretofore been classed with the orders mentioned

above, under the subclass Gymnolaemata of Allman. In this paper I have tried to show that the ancestors of the Gymnolaemata belonged to a still more primitive race and that the Trepostomata represented this race at the zenith of its evolution.

From a purely theoretical standpoint the Entoprocta are considered ancestral to the Ectoprocta. The very fact that no living entoproct could lend itself to fossilization prevented paleontologists from recognizing that a group represented now by a handful of "living fossils" might, and probably did, have forms capable of preservation. In comparing the Trepostomata with the Entoprocta and especially with *Urnatella* I have tried to show that the Trepostomata were such a group; that the Trepostomata were Entoprocts.

Of course we can never know the position of the anal opening in a zooid of the Trepostomata, nor will it ever be possible to prove the absence of a true body cavity, and so all that can be said must remain speculation.

"Speculation, even of the happiest kind, can do no more than point the way to future knowledge. Though it may stand on the right path, the signpost it not the goal itself."

Postscript

The preceding paper represents the second of two publications by Dr. George B. Twitchell which rank as extraordinary contributions to paleontology by one who called himself an amateur paleontologist. The first one, on "The structure and relationship of the true Stromatoporoids," was published in this Journal in 1929, vol. 11, pp. 270-306. Both papers are fine examples of interpretations that grew by inductive reasoning out of a wide acquaintance with modern forms of life, the sort of understanding which was peculiar to the naturalists of the nineteenth century, in which Dr. Twitchell began his work.

Since his boyhood days, when the early death of his father destroyed his hopes of studying zoology, Dr. Twitchell had collected and studied freshwater life. The sponges and bryozoans attracted him especially. The same streams in the vicinity of Cincinnati in which he loved to search for the living magic he found in them — to use his own words — offered him in their banks a wealth of fossil marine bryozoa and also some sponges. These he included early in his diligent collecting and before long made them major objects of study. The two papers which have sprung from these two lines of search insure for him a place of honor among paleontologists.

In April, 1933, Dr. Twitchell decided to subject himself to an operation which few realized he had little chance of surviving. In the days that were to be his last he used all available time to put on paper the facts and ideas concerning trepostomatous bryozoans whose study had filled his leisure hours for years. He showed once again the microscopic slides he considered critical and outlined the main points of his argument.

In revising the first draft of the paper left to him for this purpose, the writer retained as far as possible the wording of the original. The subject matter required recasting. Connecting phrases and paragraphs were added throughout the paper, together with the bibliographic references. The illustrations were chosen from slides set aside by Dr. Twitchell for this purpose. The photographic work was done by Mr. Michael S. Chappars, to whom the writer wishes to express his sincere thanks.

In turning over these pages to the scientific public, the writer has but one regret: that facts and thoughts can be transmitted, but not the charm of the rare human qualities of the man from whom they were received.

Walter H. Bucher,
University of Cincinnati.

PLATE XXVIII

FIGURES

1. *Ascopodaria macropus* Ehlers. Growing from stolons attached to an alga *(Caulerpa)*. Collected in the harbor of Cartagena, Spain. (Reproduced from Ehlers 1890, op. cit., pl. 1, fig. 2). (Enlarged about 20 times.)

2. *Pedicellina echinata* S. Young colony detached from its support, showing the segmented stolon and the soft-cuticled, calyx-bearing stalks covered with glandular spines. (Reproduced from Ehlers 1890, op. cit., pl. 1, fig. 4).

3. *Urnatella gracilis* Leidy. Single polyp, showing segmentation of stem and budding from lower parts of segments. (After Leidy, from Ward and Whipple, "Fresh-water Biology," 1918, p. 951, fig. 1394 b).

4. *Urnatella gracilis* Leidy. Colony, showing basal plate, one segmented stem arising from it, bearing additional polyp-bearing stems produced by budding from segments. Illinois River at Havana, Ill. (After Davenport, from same source as fig. 3). (Enlarged about 18 times.)

5. *Urnatella gracilis* Leidy. Showing three stems arising from a basal plate. (After Davenport, from H. S. Pratt, "A Manual of the Common Invertebrate Animals," 1916, p. 247, fig. 404).

PLATE XXVIII

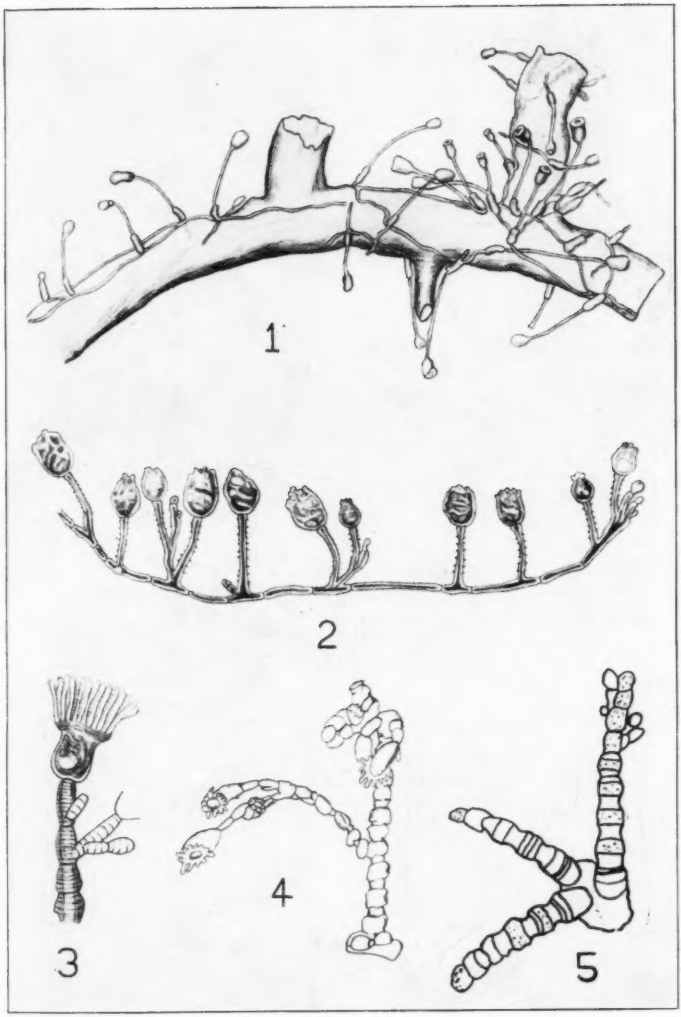


PLATE XXIX

FIGURES

6. *Peronopora vera* Ulrich. Tangential section of the pseudo-epitheca on the underside of a large basal plate. Shows the simple character of the stolon tubes with their uniformly spaced diaphragms.

7. *Aspidopora eccentrica* (James). Section tangential to base. Shows the stolons radiating from a point that lay close to the margin of the colony.

8. *Peronopora vera* Ulrich. Longitudinal section across the same specimen as fig. 6. Shows the vertical, cystiphragm-bearing zooecia arising from prostrate stolons.

9. *Peronopora vera* Ulrich. Shows zooecia arising from stolons encrusting a crinoid column which became detached in the process of mounting the slide. The stolons are seen in cross-section, like a pavement of angular blocks at the base of the zooecia. They also appear in a similar fashion in the lamina that separates the two sides of the bifoliate frond.

10. *Monticulipora molesta* Nicholson. Longitudinal section of colony attached to brachiopod shell, showing irregularly oval cross-section of the stolons of the basal plate.

11. *Monticulipora epidermata* Ulrich and Bassler. Longitudinal section of colony showing considerable stretches of the stolons of the basal plate cut lengthwise and the zooecia arising from them.

PLATE XXIX

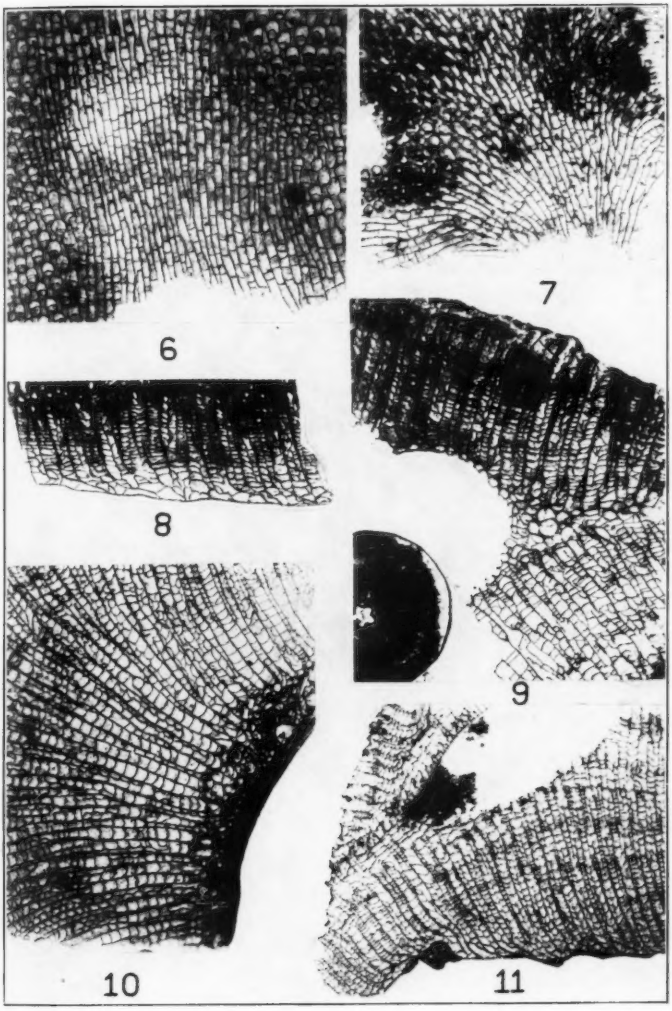


PLATE XXX

FIGURES

12. *Heterotrypa frondosa* (D'Orbigny). Longitudinal section of the base of a frond attached to *Monticulipora*. Portion shown here is cut along a stolon through a central unit which may represent the protoecium (at the lower end of the tube marked X). From it zooecia are seen budding in all directions.

13. *Peronopora vera* Ulrich. Section cut in the plane which separates the two sides of the bifoliate colony. The appearance of the stolons is identical with that seen in the basal plate. (Compare Fig. 6 on Plate 28.)

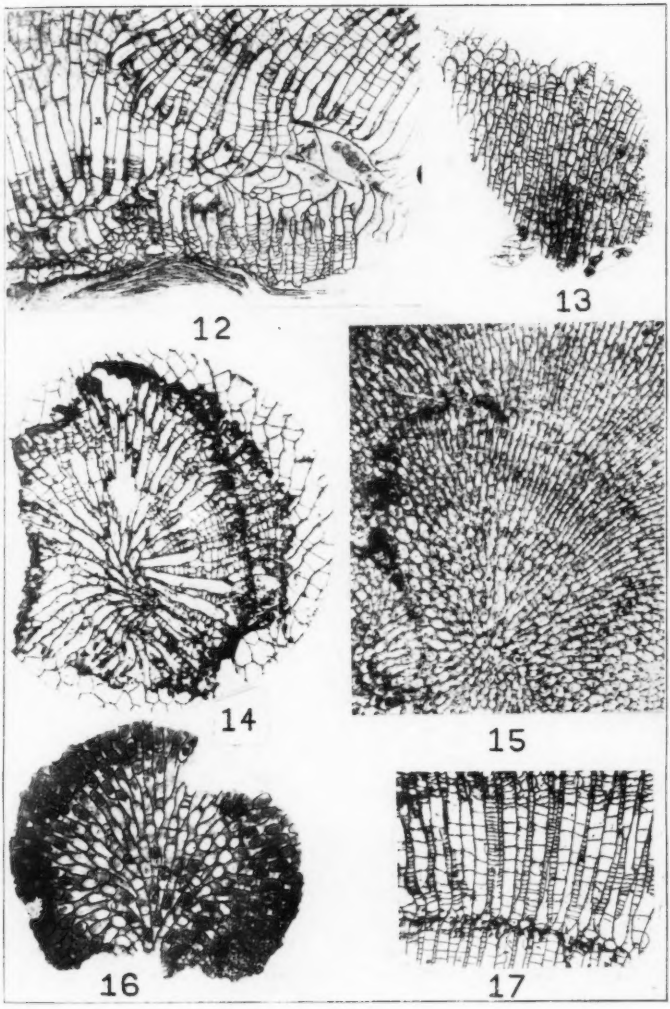
14. Section tangential to base of an unknown trepostome bryozoan, overgrown by *Rhombotrypa* sp. It shows the eccentric budding of the stolons which is common to many forms.

15. *Peronopora vera* Ulrich. Shows part of a complete basal plate showing the stolons radiating from a point above the zooecium. Because of the uneven character of the plate, the stolons show well only in the upper right quarter of the figure.

16. *Aspidopora eccentrica* (James). Shows the stolons radiating from a point that lay close to the margin of the colony.

17. *Homotrypella hospitalis* (Nicholson). Longitudinal section, showing the more or less oval cross-sections of the stolons at the base of an overgrowth. Only the uppermost part of the older growth is preserved in the section, showing the characteristic accumulation of brown material immediately beneath the overgrowth.

PLATE XXX



A REVISION OF THE GENUS LEIOBUNUM (OPILIONES) OF THE UNITED STATES

NORMAN W. DAVIS

By far the greater number of Harvestmen or Opiliones which are noticed by the casual observer on the sides of buildings, on the trunks of trees or under boards or logs belong to the genus Leiobunum. Little work has been done on the ecology of American Harvestmen and nearly all of what is known concerns the species found in the eastern states. Here they have a range of habitats extending from sandy oak ridges to low moist hardwood forests. Some species occur in several very different environments while others only in one. An example of the first case is *bimaculatum* which can be found in hardwood forests, pine woods, scrub oak or sand scrub. The other extreme is found in *bicolor* which has been taken only in the immediate vicinity of a stream in woods or in wooded areas.

The greater number of the members of this genus mature in July, in Florida as well as in New York. However *ventricosum* winters over as a partly grown nymph and reaches sexual maturity about the first of June. In New York State and probably elsewhere *bicolor* matures in the latter part of September or the first of October and winters over in the adult stage.

There has been considerable confusion as to the identity of several species of Leiobunum, due in part to the large amount of variation found in some of the species but largely to the fact that all of the older authors' types have been destroyed or lost. This paper is an attempt to lessen such confusion.

The specimens used by Miss Walker in her "Revision of the Phalangida of Ohio" are in the collection of Ohio State University. The types of Thomas Say's species were destroyed by fire. Those of Horace C. Wood, Jr. are believed to be lost. Clarence M. Weed's types ar also lost. Nathan Bank's types are in the Museum of Comparative Zoology at Cambridge. The types of species described by Crosby and Bishop and by myself are in the Cornell University Collection.

C. Fr. Roewer described a species of Leiobunum from Oregon as *ephippiatum* in 1910. As I have been unable to examine specimens of this species, it is not included in the key. A translation of Roewer's description in "Die Weberknechte der Erde" is included.

A number of persons have contributed information, assistance, or material for this work. Mr. Nathan Banks, Miss Mary Walker, Dr. W. M. Barrows and Dr. S. C. Bishop have all very kindly allowed me to examine the material in their collections. Professor C. R. Crosby has given much friendly advice and constructive criticism. Professor T. H. Hubbell has contributed much of the material.

Genus *Leiobunum* C. L. Koch

Uebersicht des Arachnidensystems 2:35. 1839.

Body soft or dorsally subcoriaceous. Length and breadth of eye tubercle equal to height, often armed with a row of small tubercles over each eye. Frontal margin of carapace without median protuberance. Surface of dorsum practically unarmed. (In *aurugineum* covered with numerous small tubercles). First five tergites sometimes fused into a stiff scutum in male. Coxae often with marginal row of denticles, less often with only anterior row of first coxa and posterior row of fourth coxa present. First segment of chelicera dorsally smooth. Patella of palpus without distomesal apophysis although sometimes swollen on the distomesal angle. Terminal claw of palpus serrate. Tarsus of palpus of male armed with a longitudinal row of small tubercles on mesoventral surface. These tubercles lacking on female. Legs usually exceedingly long and slender. First femur usually much longer than body, very seldom *(aurugineum)* only as long as, or slightly longer than body. Second legs always longest, much longer than fourth legs.

Type: *Phalangium rotundum* (Latrielle). Designated by Simon, Arach. France 7:172. 1879.

KEY TO MALES

1. Penis in dorsal view consisting only of a scleritized shaft ---------- 2
   Penis in dorsal view with a thin membranous part (alate part) near apex of shaft ---------- 14
2. Femur of palpus with a distinct ventrolateral spur ---------- *calcar*
   Femur of palpus not so armed ---------- 3
3. Femur of palpus with a ventrolateral raised area bearing large black tubercles ---------- *serratipalpe*
   Femur of palpus not so armed ---------- 4
4. Femur, patella and tibia of palpus plainly incrassate ---------- *crassipalpe*
   Femur, patella and tibia of palpus not incrassate ---------- 5
5. Femur of palpus slender, extending above surface of carapace a distance equal to three times the height of the eye tubercle ---------- 6
   Femur of palpus extending above surface of carapace less than twice the height of the eye tubercle ---------- 7
6. Abdomen long and pointed behind, central marking distinct ---------- *vittatum*
   Abdomen bluntly rounded behind, central marking usually obsolete ---------- *speciosum*
7. Legs with white annulations ---------- 8
   Legs with no white annulations often with brown or black annulations ---------- 10
8. Lateral surfaces of trochanters and bases of femora of legs lighter than shafts of femora in color, penis a long cylinder abruptly contracting into a short tip at apex ---------- 9
   Lateral surfaces of trochanters and bases of femora of legs concolorous with shafts of femora, penis broad basally tapering quickly into a long very narrow shaft ---------- *relictum*
9. From eastern United States ---------- *bicolor*
   from western North America ---------- *paessleri*
10. Trochanters black contrasting strongly with coxae ---------- 11
    Trochanters yellow to golden brown, concolorous or nearly concolorous with coxae ---------- 13
11. Femora banded with black or dark brown distally ---------- *formosum*
    Femora dark brown or black not banded ---------- 12

12. Distal end of femur, and all of patella and tibia of palpus black ... *nigropalpi*
Palpus golden-yellow ... *uxorium*

13. Legs shaded to dark brown distally, shaft of penis roughly cylindrical, laterally compressed near tip, body 5 mm. or less in length ... *politum*
Legs uniform golden-brown or golden, shaft of penis a straight taper from base to tip, strongly dorso-ventrally flattened, body 6 mm. or more in length ... *flavum*

14. Dorsum brown or black with conspicuous whitish spots near union of carapace with abdomen; trochanters brown ... *bimaculatum*
Dorsum without such markings; trochanters brown or black ... 15

15. Apices of femora of legs banded with white ... *townsendi*
Femora of legs without such markings ... 16

16. Femur, patella and tibia of palpus black ... *exilipes*
Palpus brown or yellow ... 17

17. Trochanters of legs black contrasting with coxae and much darker than dorsum ... 18
Trochanters of legs brown or yellow, not contrasting with coxae and no darker than dorsum ... 20

18. Apex of tibia II with a white band ... *longipes*
Apex of tibia II without white band ... 19

19. Legs light brown proximally, shaded distally, dorsum brown contrasting with yellowish white venter ... *verrucosum*
Legs uniform dark brown to black, dorsum orange-yellow, only slightly darker than venter ... *nigripes*

20. Dorsal surface of abdomen strongly arched as seen from side, covered thickly with sturdy retrorse tubercles ... *aurugineum*
Dorsal surface of abdomen nearly flat, very few or no tubercles present ... 21

21. Dorsal surface of shaft of penis arched to form a medial longitudinal keel ... *depressum*
Dorsal surface of shaft of penis without medial longitudinal keel ... 22

22. Dorsum brown contrasting with yellowish white venter ... *peninsulare*
Dorsum concolorous with or very slightly darker than venter ... 23

23. Body 5 mm. or less in length, legs darker than dorsum at least distally ... 24
Body 6 mm. or less in length, legs concolorous with dorsum ... 26

24. Femur of palpus with a longitudinal row of tubercles on ventral surface ... *cretatum*
Femur of palpus armed only with hairs ventrally ... *politum*

25. Abdomen long and pointed behind ... *ventricosum*
Abdomen truncate or bluntly rounded behind ... *flavum*

Key to Females

Females of the species of this genus are very difficult to determine, and in using the following key allowance must be made for the fact that more or less variation occurs. When possible females should always be determined by comparison and association with males.

1. Legs with white annulations (sometimes only a faint band at apex of tibia II) ... 2
Legs with no white annulations, often with brown or black annulations ... 9

2 Trochanters of legs black ... 3
Trochanters of legs yellow ... 5

3. Palpus marked with black ... *exilipes*
Palpus yellow ... 4

4. Apex of tibia II banded with white ... *longipes*
Apex of femur IV banded with white ... *uxorium*

5. Tarsi of legs with white annulations at articulations ... 6
Tarsi of legs not so marked ... 7

6. From eastern United States ..... *bicolor*
   From western States ..... *paessleri*
7. Femora or tibae of legs banded with brown or brown and white distally 8
   Femora or tibae of legs not so marked ..... *politum*
8. Eye tubercle unarmed, central marking indistinguishable caudad ..... *townsedi*
   Eye tubercle with well developed rows of tubercles, central marking distinct the length of the dorsum ..... *relictum*
9. Lateral surface of trochanters of legs dark brown or black, contrasting with coxae, darker than dorsum except central marking 10
   Lateral surfaces of trochanters of legs concolorous with coxae, or no darker than dorsum 18
10. Venter nearly concolorous with dorsum, femur of palpus extending above surface of carapace a distance equal to twice the height of eye tubercle ..... *speciosum*
    Venter distinctly lighter than dorsum in color, femur of palpus extending above surface of carapace a distance of no greater than height of eye tubercle 11
11. Legs with conspicuous brown or black annulations 12
    Legs uniformly colored or distally shaded 13
12. Length of body 10 mm., central marking faint ..... *formosum* or *nigripes*
    Length of body 8.5 mm. or less, central marking conspicuous ..... *vittatum*
13. Legs black or very dark brown 14
    Legs light brown 16
14. Dorsum dark brown, body 7.5 mm. or more in length 15
    Dorsum light brown, body 6.5 mm. long ..... *uxorium*
15. Femur of palpus extending above surface of carapace a distance equal to to height of eye tubercle ..... *vittatum*
    Femur of palpus extending above surface of carapace a distance equal to one-fourth height of eye tubercle ..... *nigripes*
    Trochanters of legs dark brown ..... *calcar*
    Trochanters of legs black 17
17. Palpi marked with dark brown ..... *nigropalpi*
    Palpi yellow-white ..... *verrucosum*
18. Dorsum brown or black with conspicuous whitish lateral markings ..... *bimaculatum*
    Dorsum without such markings 19
19. Cephalic and caudal surfaces of trochanters of legs much darker than lateral surfaces ..... *depressum*
    Trochanters of legs uniformly colored 20
20. Dorsal surface of abdomen thickly covered with sturdy retrorse tubercles, strongly arched as seen from side ..... *aurugineum*
    Dorsal surface of abdomen without retrorse tubercles 21
21. Body 4 mm. long ..... *cretatum*
    Body 6 mm. or more in length 22
22. Body 7 mm. or less in length, venter contrasting sharply with dorsum ..... *peninsulare*
    Body 9 mm. or more in length, venter only slightly lighter than dorsum 23
23. Abdomen long and pointed behind ..... *ventricosum*
    Abdomen rounded behind ..... *flavum*

Leiobunum aurugineum Crosby and Bishop

Leiobunum aurugineum Crosby and Bishop, Elisha Mitchell Sci. Soc. Jour. 40:13-14, pl. 2, f. 8. 1924.

Male. Average length, 6.5 mm.; average length of legs I, 24; II, 48; III, 25; IV, 38 mm.

Dorsum with a scattering of tubercles along the cephalic margin of cara-

pace leaving a triangular area around eye tubercle granulated but not tuberculate. Eye tubercle low, rounded, with a row of five or six sturdy tubercles over each carina. Behind the eye tubercle a high transverse fold armed with larger black-tipped tubercles. Behind this a deep transverse groove extending to a point above caudal margin of third coxa. Caudad of this groove is a higher, wider fold similarly armed and followed by another groove extending behind caudal margin of fourth coxae. Abdomen somewhat pointed posteriorly. Dorsum of abdomen strongly arched as seen from side and covered with sturdy retrorse tubercles. Venter: free sternites armed with small tubercles. These tubercles thicker on genital operculum and coxae. Genital operculum and coxae I, II, and IV each armed with two marginal rows of wedge-shaped denticles, posterior row lacking on coxa III.

Palpus: femur slender, slightly arched distally, extending above surface of carapace 1/3 to 2/3 height of eye tubercle, armed dorsally with a few scattered black hairs and a few black-tipped tubercles at distal end, ventrolaterally with an irregular row of black-tipped tubercles; ventromesally with a row of smaller brown tubercles, and ventrally with black hairs. Patella one-half as long as femur; armed dorsally with black-tipped tubercles, a ring of these around distal end; ventrally covered only with scattered black hairs. Tibia a little longer than patella, armed dorsally with black hairs, ventrally with black hairs and a few black-tipped tubercles. Tarsus a little longer than femur, slightly curved, mesoventral row of tubercles distinct proximally, usually irregular and formed of smaller tubercles distally. Penis 3.6 mm. long, alate part .6 mm. long and extends to a point 1 mm. or 1.5 mm. from distal end. Shaft of penis a flat blade with heavily soleritized lateral margins with tapers distally to a tip shaped as a spear head. Tip curved dorsally. Legs moderately slender.

Dorsum, trochanters, and legs brown, nearly concolorous. Central marking obsolete or subobsolete. Eye tubercle concolorous with dorsum. Venter including coxae a little lighter than dorsum. Palpus with femur and patella slightly darker than tibia and tarsus.

Female. Average length, 8 mm. Average length of legs I, 24; II, 48; III, 26; IV, 32 mm.

Dorsum more strongly arched than in male. Abdomen rounded caudad. Palpus: femur more slender than male, extending to the level of surface of carapace.

General coloration similar to male. Central marking usually subobsolete. Dorsum slightly darker than in male.

Holotype ♂. Billy's Island, Okefinokee Swamp, Georgia, June 1912, 1 ♂ and 4 ♀.

South Carolina: Colleton Co., Sept. 25, 1930, 4 ♂, 1 ♀ (Hubbell). *Alabama:* Daphne, July 19, 1931, 2 ♂ (Dietrich). *Georgia:* Stockton, Nov. 1, 1929, 1 ♂ 1 ♀ (Hubbell); Faceville, Sept. 12, 1929, 15 ♂ and ♀ (Hubbell); Mattox, Oct. 1, 1929, 25 ♂ and ♀ (Hubbell); Charlton Co., Sept. 29, 1929, 20 ♂ and ♀ (Hubbell); Eldorendo, Sept. 12, 1929, 1 ♀ (Hubbell); Bacon Co., Oct. 2, 1929, 1 ♀ (Hubbell); Midway, Oct. 3, 1930, 6 ♂ and ♀ (Hubbell); Camden Co., Sept. 27, 1930, 5 ♂ and ♀ (Hubbell); Emanuel Co., Nov. 2, 1929, 1 ♀ (Hubbell); Valdoata, Oct. 26, 1926, 1 ♂; Okefinokee Swamp, May 20, 1912, 1 ♂ (Crosby)

(Paratypes); Spring Creek, Sept. 25, 1910, 1 ♀ (Bradley); St. Simons Island, May 1911, 1 ♂ (Bradley); Okefinokee Swamp, June, 1 ♂, June 16, 1912, 1 ♂, 2 ♀, June, 1912, 1 ♀ (Crosby and Bishop); Dewitt, Apr. 1912, 4 imm., Mar. 1913, 10 imm. (Spooner); Okefinokee Swamp, July-September, 1912, 1 ♂ (Lee); Bainbridge, July 16, 1909, 1 ♂ (Bradley); Thomasville, Mar. 1, 1910, 1 imm. (Miller). *Florida:* Rock Bluff, Apr. 4, 1927, 5 imm.; Micanopy, May 9, 1926, 3 ♂ (Hubbell); Green Cove Springs, Feb. 22, 1927, 1 imm. (Leonard); Micanopy, Mar. 6, 1927, 1 imm. (Leonard); Sanford, Sept., 1927, 1 ♀ (Stone); Tallahassee, Apr. 13., 1927, 20 ♂ and ♀; Cocoa, Oct. 27, 1925, 1 ♂ (Leonard); De Funiak Springs, Sept. 11, 1929, 125 ♂ and ♀ (Hubbell); Wellborn, Sept. 9, 1929 55 ♂ and ♀ (Hubbell); Dixie Co., Sept. 5, 1929, 1 ♂, 6 ♀ (Hubbell); Chattahoochie, Sept. 12, 1929, 1 ♂ (Hubbell); Tallahassee, Sept. 10, 1929, 30 ♂ and ♀ (Hubbell); Columbia Co., Nov. 26, 1929, 2 ♀ (Hubbell); Liberty Co., Sept. 11, 1929, 12 ♂ and ♀ (Hubbell); Hamilton Co., Oct. 26, 1929, 10 ♂ and ♀ (Hubbell); Monticello, Oct. 12, 1929, 2 ♂, 3 ♀ (Hubbell); Callahan, Nov. 28, 1929, 10 ♂ and ♀ (Hubbell); Chattahoochie, June 11, 1930, 1 ♂ (Van Hyning); Alachua Co. (neighborhood of Gainesville) Mar.-Nov., many specimens (Hubbell).

Leiobunum bicolor (Wood)

Phalangium bicolor Wood, Essex Inst. Commun. 6:28, 39, f. 1870.
Phalangium bicolor Underwood, Can. Ent. 17:168. 1885.
Liobunum bicolor Weed, Am. Nat 21:935. 1887.
Leiobunum bicolor Weed, Ill. State Lab. Nat. Hist. Bull. 3:103. 1889
Leiobunum elegans Weed, Ill. State Lab. Nat. Hist. Bull. 3:89, 102. 1889.
Astrobunus bicolor Weed, Am. Nat. 24:918. 1890.
Leiobunum elegans, Am. Nat. 24:918. 1890.
Leiobunum bicolor Weed, Am. Nat. 27:295. 1893.
Leiobunum bicolor, U. S. Nat. Mus. Proc. 16:552, pl. 64, 65. 1893.
Leiobunum bicolor Weed, Am. Ent. Soc. Trans. 20:290. 1893.
Leiobunum bicolor Banks, N. Y. Ent. Soc. Jour. 2:145. 1894.
Leiobunum bicolor Banks, Am. Nat. 35:676. 1901.
Leiobunum bicolor Roewer, Naturw. Ver. Hamburg Abh. 19 (4):223, pl. 5, f. 23. 1910.
Leiobunum bicolor Comstock, Spider Book, p. 73. 1912.
Leiobunum bicolor Roewer, Weberknechte p. 901. 1923.
Leiobunum bicolor Walker, Ohio Biol. Surv. Bul. 19:164, pl. 2, f. 15. 1928.
Leiobunum annulatum Walker, Ohio Biol. Surv. Bul. 19:167, pl. 2, f. 20. 1928.

Male. Average length 5.5 mm.; average length legs I, 35; II, 63; III, 37; IV, 48 mm. (one specimen from North Carolina 7 mm. long with legs 37; 68; 40; 55 mm. long respectively).

Dorsum finely granulated, anterior margin of carapace unarmed, eye tubercle rounded, deeply canaliculate, the rows of tubercles over each carina present but indistinct and formed of small, low tubercles. Abdomen pointed caudad. Venter: free sternites and genital operculum unarmed. Coxae finely tuberculate, marginal rows of denticles poorly developed on coxae I and II, lacking on coxae III and IV.

Palpus: femur slender, slightly curved, extending above surface of carapace to approximately the height of eye tubercle; distolaterally with an area of black-tipped tubercles, this area tapering proximally until it becomes only a narrow ventrolateral border; dorsal surface with a very few such tubercles on distal portion; armed mesally and ventrally with numerous tubercles, those on ventral surface usually somewhat smaller. Patella armed laterally and mesally with numerous black-tipped tubercles and many brown hairs;

dorsally a narrow area in the form of a medial longitudinal stripe which is entirely unarmed, other similar areas sometimes present dorsolaterally. Tibia with similar areas dorsally and dorsolaterally; armed laterally, dorsally, (except in areas mentioned above) and dorsomesally with many brown hairs, a number of black-tipped tubercles laterally anl dorsomesally; ventrally and ventromesally usually armed only with a few hairs. Tarsus with many hairs, mesoventral row of tubercles distinct, a less distinct lateroventral row of more widely spaced tubercles also present. Penis 2.6 mm. long, alate part .8 mm. long, and extending to a point .5 mm. from the distal end. Shaft of penis a flat blade with heavily scleritized lateral margins, slightly broadened at the base; distally the blade is truncated and the tip protruding from this truncated end. Alate part not as wide as blade and therefore not visible from dorsal view. Legs of normal length and diameter.

Dorsum golden to brown, dorsal markings exceedingly variable. Anterior margin of carapace yellow, lateral margins edged with dark brown or black. Entire dorsum often with irregular yellow splotches. A dark triangular mark nearly always present just caudad of eye tubercle. A number of transverse dark lunate bands sometimes on abdomen. Caudal part of abdomen usually somewhat darker than rest of dorsum. Eye tubercle black dorsally, lighter below in front. Venter light yellow, free sternites sometimes darker along lateral margins of venter, coxae often darker at apices. Palpus: femur yellow proximally, brown distolaterally and distomesally, a longitudinal yellow stripe distodorsally. Patella brown on sides with one or more such stripes dorsally. Tibia yellow ventrally and mesally, brown dorsally and laterally with one or more stripes dorsally. Tarsus yellow. Trochanters pale laterad, concolorous with coxae; mesal side darker but not darker than dorsum. Legs dark brown ringed with white at all articulations including those of the tarsi and the false ones of the metatarsi.

Female. Length 7.5 mm.; length legs I, 37; II, 66; III, 42; IV, 50 mm. (measurements taken from one adult from Ohio and two adults from New York).

Abdomen rounded caudad. Femur of palpus slightly shorter than in male. Palpus with fewer tubercles. General coloration same as male.

Type ♀. Delavan Co., Pennsylvania.

Vermont: South Newfane, June, 1927, 1 ♂ (Bryant). *New Hampshire:* Franconia, 1 ♂, 1 ♀ (Banks). *New York:* Montour Falls, Sept. 21, 1924, 14 imm.; Enfield Glen, Aug. 14 - Sept. 30, 12 ♂, 10 ♀, 13 imm. (Hayden, Hughes); Wilmington, Aug. 26, 1916, 5 imm. (Crosby); Ithaca, Dec. 2, 1906, 1 ♂, Jan. 4, 1907, 1 ♂; Enfield Center, May 30, 1906, 1 ♂ (Rea); Caroline, May 5, 1912, 1 ♂ (Crosby; Rock City, Sept. 16, 1925, 1 specimen; Meadowdale, May 29, 1920, 1 ♀; McLean, Apr. 17, 1925, 1 ♂, May 14, 1919, 1 ♂; Essex Co., June 28, 1923, 1 specimen; (Crosby), Aug. 29, 1926, 2 ♂; Hornell, Sept. 15, 1925, 1 ♂; Lewis Co., 1 specimen, Sept 2, 1926, Sept. 1, 1926, 1 specimen. *Pennsylvania:* Orangeville, Aug. 11, 1932, 1 imm., Aug. 12, 1932, 1 imm. (Hughes). *Ohio:* Hocking Co., 3 ♂, 8 ♀ (Walker), May 23, 1932, 1 ♂ (Crosby. *Kentucky:* Quicksand. June 23, 24, 1925, 1 ♂, 3 imm.; Mammoth Cave, 1 ♂, 2 imm. (Putnam), 2 ♂. *North Carolina:* Blowing Rock, Oct. 10, 1923, 1 ♂ (Crosby); Grandfather Mountain, Oct. 12, 1923, 1 ♂ (Crosby); Frying Pan Gap, Oct. 13, 1926, 1 ♂; Blowing Rock, Sept. 8, 3 ♂, 4 ♀ (Banks). *Tennessee:* Mt. Le Conte, Oct. 7 - 10, 1926, 3 ♂ (S. Bishop).

Leiobunum bimaculatum Banks

Leiobunum bimaculatum Banks, Can. Ent. 25:210. 1893.
Leiobunum bimaculatum Banks, Am. Nat. 35:676. 1901.
Leiobunum bimaculatum Banks, Cal. Acad. Sci. Proc. 3:361. 1904.
Leiobunum bimaculatum Roewer, Naturw. Ver. Hamburg Abh. 19 (4):229. 1910.
Leiobunum bimaculatum Banks, Pomona J. Ent. 3:421. 1911.
Leiobunum bimaculatum Comstock, Spider Book, p. 73. 1912.
Leiobunum bimaculatum Roewer, Weberknechte p. 905. 1923.
Leiobunum bimaculatum Crosby and Bishop, Elisha Mitchell Sci. Soc. Jour. 40:13-16, pl. 2, f. 11, 12. 1924.

Male. Average length 4 mm.; average length legs, I, 49; II, 90; III, 49; IV, 65 mm.

Dorsum uniformly granulated; anterior margin of carapace sometimes furnished with a few small tubercles. Eye tubercle as high as wide, shallowly canaliculate, and armed with a row of two to four tubercles over each carina. A few tubercles scattered along caudolateral margins of dorsal scutum and on free tergites. Abdomen subtruncate or very bluntly rounded caudad. Venter: free sternites and genital operculum with scattered white tubercles; tubercles much more closely spaced on coxae. Coxae I - III with a well developed row of wedge-shaped denticles on anterior margin, coxa IV with such rows on both margins. Marginal rows of wedge-shaped denticles entirely lacking on genital operculum.

Palpus: femur slender, straight, extending but little above surface of carapace, armed ventrally with two rows of white tubercles. Patella with its inner distal angle swollen and covered with white hairs. Tibia armed with scattered white tubercles. Tarsus slightly curved and distally swollen, mesoventral row of tubercles very small and concolorous with tarsus. Penis 2.5-3 mm. long, alate part .6 mm. long and extends to a point .5 mm from distal end. Proximal part of penis a flat blade with heavily scleritized lateral margins; this blade not laterally compressed at base of alate portion as in *L. peninsulare*, terminating in a tip which is strongly compressed laterally and is bent dorsally. Legs moderately slender.

Dorsum dark brown to black, central marking faint or subobsolete. Eye tubercle light in front, dark brown or black elsewhere. Lateral margins of scutum furnished with characteristic white markings, most noticeable near union of carapace with fused abdominal tergites, sometimes, particularly in immatures, forming an irregular light band extending to cephalic and sometimes to caudal margins of dorsum. Venter a silvery-white or light yellow. Chelicerae concolorous with venter. Palpi very slightly darker.

Female. Average length 7.5 mm. Average length legs, I, 45; II, 78; III, 46; IV, 64 mm.

Abdomen somewhat pointed caudad. Central marking more distinct than in males due partly to the greater number of lateral white markings. Dorsum of abdomen often a lighter brown along markings and between tergites.

Type, ♂, collection Harvard Museum of Comparative Zoology.

Virginia: Virginia Beach, 1 ♂ (Caudell). *South Carolina:* Jasper Co., Oct. 3, 1930, 3 ♂, 4 ♀ (Hubbell). *Mississippi:* New Augusta, Oct. 22, 1931, 1 ♂ (Die-

trich); Lucedale, Sept., 1931, 4 ♂, 10 ♀, Oct. 1, 1931, 2 ♂, 8 ♀, Feb., 1932, 1 ♀, Aug., 1931, 4 ♂, 2 ♀, Sept. 25, 1931, 4 ♂, 11 ♀, June, 1932, 1 ♂, Dec., 1930, 1 ♂ (Dietrich); Hattiesburg, Nov. 19, 1931, 1 ♀ (Dietrich); Ocean Springs, 1 ♂, June, 1905, 4 ♂, 2 ♀ (Comstock); Agricultural College, fall 1916, 2 ♀ (Bailey). *Alabama: Mobile*, Oct. 14, 1931, 2 ♂ (Dietrich); Tuskegee, June 10, 1919, 1 imm.; Auburn, July 20, 1924, 1 ♂, 1 imm. *Georgia:* Lyons, Nov. 3, 1929, 7 ♂, 4 ♀ (Hubbell); Adel, Oct. 26, 1929, 7 ♂, 4 ♀; Stockton, Nov. 1, 1925, 3 ♂, 2 ♀ (Hubbell); Valdosta, Oct. 26, 1929, 3 ♂, 3 ♀; Decatur Co., June 7, 1911, 2 ♂ (Bradley); Okefinokee Swamp, June 1, 1912, 4 ♂, 1 ♀ (Crosby); May 22, 1912, 1 ♀ (Wright); Thunderbolt, June 26, 1912, 2 ♀; Tifton, Sept. 9, 1910, 2 ♂, 3 ♀ (Bradley); Dewitt, July 23, 1912, 2 ♂ (Leonard); Bainbridge, Sept., 1910, 1 ♂, 3 ♀ (Bradley); Spring Creek, Sept., 1910, 2 ♂, 3 ♀ (Bradley); Waynesville, Sept. 10, 1909, 1 ♂ (Bradley); Waycross, May 8, 1911, 1 imm. (Bradley); Stone Mountain, Oct., 1910, 1 ♂ (Bradley). *Florida:* Newberry, 5 ♂, 2 ♀; Orlando, May, 1926, 2 ♂; Micanopy, July 9, 1927, 1 ♂ (Leonard); Ocala, Apr., 1 imm. (Leonard); Columbia Co., Oct. 26, 1929, 1 ♀ (Hubbell); Nassau Co., Nov. 28, 1929, 2 ♂, 1 ♀; Wellborn, Nov. 9, 1929, 1 ♂; Marianna, July 24, 1930, 1 ♂; Santa Rosa Co., July 26, 1930, 2 ♂; Monticello, July 24, 1930, 2 ♂; Chattahoochie, June 11, 1930, 3 imm.; Hamilton Co., Oct. 26, 1929, 1 ♀ (Hubbell); Sarasota, Aug. 14, 1910, 1 ♀ (Bradley); Hawthorne, Oct. 20, 1931, 1 ♂ (Hubbell); Alachua Co., (neighborhood of Gainesville) Mar.-Oct. Many specimens (Hubbell).

Leiobunum calcar (Wood)

Phalangium calcar Wood, Essex Inst. Commun. 6:26, 39, f. 6. 1870.
Phalangium calcar Underwood, Can. Ent. 17:168. 1885.
Leiobunum calcar Weed, Am. Nat. 21:935. 1887.
Leiobunum calcar Weed, Ill. State Lab. Nat. Hist. Bul. 3:82, 90, 102. 1889.
Leiobunum calcar Weed, Am. Nat. 24:918. 1890.
Leiobunum calcar Weed, U. S. Nat. Mus. Proc. 16:553. 1893
Leiobunum calcar Weed, Am. Ent. Soc. Trans. 20:290. 1893.
Leiobunum calcar Banks, Am. Nat. 35:675. 1901.
Leiobunum calcar Crosby, N. Y. Ent. Soc. Jour. 12:256. 1904.
Leiobunum calcar Banks, Boston Soc. Nat. Hist. Occasional Papers 7 (10): 1. 1908.
Leiobunum calcar Roewer, Naturw. Ver. Hamburg Abh. 19 (4):218. 1910.
Leiobunum calcar Comstock, Spider Book p. 73. 1912.
Leiobunum calcar Roewer, Weberknechte p. 899, f. 1054. 1923.
Leiobunum calcar Crosby and Bishop, Elisha Mitchell Sci. Soc. Jour. 40:13. 1924.
Leiobunum calcar Crosby and Bishop, Cornell Univ. Agr. Exp. Sta. Mem. 101:1075. 1928.
Leiobunum calcar Walker, Ohio Biol. Surv. Bul. 19:163, pl. 1, f. 9. 1928.
Leiobunum brunnea Walker, Ohio Biol. Surv. Bul. 19:167, pl. 2, f. 20. 1928.

Male. Average length 6 mm. Length legs I, 26, II, 55, III, 28; IV, 40, (N. Y. State Specimens). Length 8 mm. Length legs I, 39, II, III, 41; IV, 62 mm. (South Carolina specimens).

Dorsum very finely granulated; anterior margin of carapace armed with a patch of tubercles in the median line and a patch on either side just caudad of the first coxae. Eye tubercle very shallowly canaliculate, armed with a well developed row of tubercles over each carina. Abdomen pointed caudad. Venter: free sternites smooth in Northern specimens, finely granulated in specimens from South Carolina. Genital operculum smooth proximally, usually armed with a few small tubercles distally, marginal rows of denticles irregular and poorly developed. Coxae smooth or with a number of small tubercles, marginal rows of denticles lacking on posterior side of coxae I-III and on anterior side of coxa IV.

Palpus: femur proximally slender, distally much thickened and curved approximately 45 degrees, extending above surface of carapace a distance equal to 1.5 times the height of the eye tubercle; armed distodorsally with numerous small black-tipped tubercles, armed ventrolaterally with a large, conical, spur-like process on the distal surface of which are a number of strong black tubercles. Patella short thickened, armed with scattered small tubercles and a short transverse row of large tubercles on the distodorsal margin. Tibia curved dorsally and strongly thickened proximally, armed ventrally with a number of black tubercles on the proximal portion at least and a row of tubercles ventromesally on the distal part. Tarsus slender, armed with a mesoventral row of close-set tubercles. Penis 4.8 mm. long in New York State specimens and 6.6 mm. long in southern specimens. Shaft of penis straight, slightly flattened for proximal third; then curving ventrad in the arc of a circle but returning to the level of the proximal part, then running horizontally for a short distance before bending abruptly dorsad. The part of the penis which forms the distal part of the arc is more strongly dorsoventrally flattened, at the point where the penis returns to a horizontal plane a shoulder is formed by the lateral compression of the tip. Legs of moderate length and diameter.

Dorsum golden-yellow to dark brown, usually mottled on carapace and with transverse rows of light spots on sternites. Central marking usually present but not conspicuous, obsolete on southern specimens. Eye tubercle brown above, lighter below in front. Venter golden-yellow. Palpus except tarsus varies from golden-yellow to very dark brown; tarsus yellow, sometimes clouded with dark brown. Legs including trochanters golden-yellow to brown; trochanters therefore may either contrast with or be concolorous with the yellow coxae.

Female. Average length 8 mm. Length legs I, 28; II, 60; III, 30; IV, 44 mm.

Abdomen rounded caudad. Femur of palpus not curved or thickened distally and lacking ventrolateral spur, extending above surface of carapace a distance equal to the height of the eye tubercle, armed with a number of tubercles distroventrally and a few tubercles proximoventrally. Tibia and tarsus of palpus not thickened as in male.

Dorsum chocolate-brown with yellowish or silver lateral markings. Central markings distinct. Abdomen ventrally lighter brown than dorsum sometimes with silvery areas. Coxae and femur of palpus brown sometimes dappled. Patella and tibia of palpus brownish. Trochanters concolorous with dorsum.

Type ♂. Type locality southwestern Virginia.

Canada: Saskatchewan, 1 ♂, 2 ♀ (Scudder); Ontario, Aug. 25, 1919, 1 ♂ (McDunnough); Nova Scotia, West River, Oct. 15, 1912, 3 ♂, 2♀ (Matheson). *Maine:* Green, Aug. 23, 1925, 1♂; Brunswick, 1 ♂ (Packard); Norway, 1 imm. *New Hampshire:* Franconia Notch, Aug. 21, 1925, 1 ♂; Moat Mountain, 1 ♂ (Bryant). *Michigan:* Charlevoix Co., 1♂ (Hubbell). *Indiana:* Arlington, 1 ♂ Banks. *New York:* Highmarket, Aug. 4, 1928, 1 ♂ (Needham); Long Lake, Aug. 9, 1931, 1 ♂ (Crosby); Factory Hollow, Aug., 1918, 1 ♂; Woodsworth Lake,

June 23, 1910, 1 ♂; Cinnamon Lake, July 12, 1924, 2 ♂; Washington Co., Aug. 1, 1920, 1 ♂, 1 ♀; Lewis Co., Sept. 1, 1926, 1 ♂; numerous specimens from vicinity of Ithaca. *Pennsylvania:* Orangeville, Aug. 6, 1932, 24 ♂, 7 ♀ (Hughes); Pattonville, 1 ♂, 2 ♀ (Crandall). *West Virginia:* South fork of Potomac, Aug., 1871, 1 ♀. *North Carolina:* Mt. Mitchell, July 3, 1928, 1 ♀. *Arkansas:* 1 ♂ (Chamberlin).

Leiobunum crassipalpe Banks

Leiobunum crassipalpe Banks, N. Y. Ent. Soc. Jour. 8:199. 1900.
Leiobunum crassipalpe Banks, Am. Nat. 35:675. 1901.
Leiobunum crassipalpe Banks, N. Y. Ent. Soc. Jour. 12:256. 1904.
Leiobunum crassipalpe Roewer, Naturw. Ver. Hamburg Abh. 19(4):221. 1910.
Leiobunum crassipalpe Comstock, Spider Book, p. 73. 1912.
Leiobunum crassipalpe Roewer, Weberknechte, p. 900. 1923.
Leiobunum crassipalpe Crosby and Bishop, Elisha Mitchell Sci. Soc. Jour. 40:13. 1924.

Male. Average length 7.5 mm. Length legs (one specimen: I, 35; II, 75; III, 36; IV, 50 mm.

Dorsum uniformly granulated; anterior margin of carapace furnished with a number of small tubercles in the median line. Eye tubercle canaliculate armed with a well developed row of small black-tipped tubercles over each carina. Abdomn long and pointed behind. Venter: free sternites finely granulated, not at all tuberculate. Genital operculum with a few sturdy tubercles on distal part, proximal part with fine granulations, marginal rows of denticles entirely lacking. Coxae set with numerous tubercles, marginal rows of denticles well developed on anterior side, not as well developed on posterior side particularly on coxa III.

Palpus: femur very thick and strong, curved approximately thirty degrees at distal end, extending above surface of carapace a distance equal to twice the height of the eye tubercle; armed distodorsally with a short medial row of small, forward-pointing black-tipped tubercles, laterally with an irregular row of large black-tippcd tubercles which become more numerous distally, ventrally unarmed. Patella short, much thickened, armed with a single row of long black-tipped tubercles laterally and on one specimen a number of small tubercles on the dorsoproximal area. Tibia curved, strongly thickened proximally, armed with a group of large black-tipped tubercles ventrolaterally on the proximal end which continue distally as a ventrolateral row, a short row of strong tubercles mesally on the distal end. Tarsus a little smaller in diameter in the middle than at ends, furnished with light brown hairs and armed with a mesoventral row of large black tubercles. Penis 6 mm. long, alate part lacking. Proximal part of penis an elliptical shaft which tapers abruptly into a thin quadrolateral rod with a heavily scleritized dorsal surface. Legs of moderate length and diameter.

Dorsum golden-yellow, mottled on carapace and with transverse rows of lighter spots on sternites. Central markings distinct, brown, extending from eye tubercle to penultimate segment of abdomen. Eye tubercle brown. Venter slightly lighter than dorsum. Palpus golden-yellow with faint transverse bars of a lighter color on the dorsal surface of femur. Legs: trochanters light on outer surface, concolorous or nearly concolorous with coxae; anterior

and posterior surfaces brown, concolorous with central marking of dorsum. Remainder of legs a nearly uniform brown.

Female not known.

Type, ♂, collection Harvard Museum of Comparative Zoology.

Missouri: Pulaski Co., Aug. 20, 1924, 1 ♂ (Williamson); Crawford Co., Sept. 7, 1920, 1 ♂ (Hubbell). *Oklahoma:* Oil Springs, Oct. 2, 1930, 2 ♂ (Bird).

Leiobunum cretatum Crosby and Bishop

Leiobunum cretatum Crosby and Bishop, Elisha Mitchell Sci. Soc. Jour. 40:19, pl. 2, f. 5. 1924.

Male. Average length 3 mm.; average length of legs I, 34; II, 65; III, 35; IV, 49 mm.

Dorsum finely granulated, a few golden tubercles along anterior margin of carapace. Eye tubercle high, deeply canaliculate, well armed with sturdy black-tipped tubercles over each carina. Abdomen pointed, rounded or subtruncate caudad. Venter: free sternites each armed with a transverse row of very small golden tubercles. Coxae strongly tuberculate, marginal row of denticles lacking on caudal side of coxae I - III. Genital operculum armed with only a few small golden tubercles, marginal rows of denticles lacking.

Palpus: femur slender, arched distally, extending only a very slight distance above the surface of the carapace; armed with a row of large golden tubercles on ventral side, armed distodorsally with a few scattered tubercles. Patella armed dorsally with numerous tubercles; distal ring of tubercles incomplete or lacking, unarmed ventrally. Tibia armed with a number of hairs and sometimes with a few tubercles also. Tarsus thickly covered with yellow hairs; mesoventral row of tubercles barely distinguishable at magnification of 85 diameters. Penis 1.8 mm. long, alate part .3 mm long and extending to a point .4 mm. from distal end. Proximal part of penis a flat blade with margins not scleritized more heavily than medial part. Distal part strongly compressed laterally and bent dorsally. Alate part not extending farther proxad than shoulder of blade as seen from above. Legs very slender and thread-like.

Dorsum golden-yellow, central marking obsolete. Eye tubercle light in front, dark greyish above. Venter very slightly lighter than dorsum. Palpi yellow, trochanters and bases of femora golden-yellow, nearly concolorous with dorsum. Legs distally greyish brown.

Female. Length 4 mm. Length legs I, 33; II, 66; III, 33; IV, 47 mm. Abdomen subtruncate, pointed, or rounded caudad, femur of palpus armed ventrally with only scattered small tubercles.

Holotype ♀, Oglethorpe, Georgia, July, 1910 (Bradley) Cornell Collection.

Michigan: Washtenaw Co., 1 ♂, 1 ♀ (Rogers). *Virginia:* Dyke, 1 ♀; Great Falls 1 ♂ (Banks). *Florida:* Leon Co., July 24, 1930, 30 specimens, Monticello, April 11, 1927, 1 imm. (Walker); April 6, 1927, 3 imm. (Walker); Wewahitchka, April 6, 1927, 3 imm. (Walker).

Leiobunum depressum sp. nov.

Male. Length, 4 mm. Length legs I, 25; II, 49; III, ??; IV, 47 mm.

Dorsum finely granulated, the granulations being larger and more numerous on the abdomen, no tubercles present on cephalic margin of the carapace. Eye tubercle high, canaliculate, constricted basally, armed only with a few small tubercles on the more posterior part. Abdomen truncate caudad. Venter: free sternites unarmed. Coxae armed only with a few low rounded tubercles, marginal rows of denticles present and distinct.

Genital operculum armed with a few small tubercles as on coxae and distinct rows of marginal denticles.

Palpus: femur moderate diameter, nearly straight, extending above surface of carapace about one-half the height of the eye tubercle, armd distodorsally and distolaterally with a few tubercles. Patella armed dorsally and laterally with a number of tubercles, distal ring of tubercles lacking, ventrally unarmed. Tibia armed only with hairs. Tarsus armed with many hairs, mesoventral row of tubercles distinct. Penis 2.2 mm. long. Alate part present. Shaft of penis short and heavy, ventral surface rounded, dorsal surface arched to form a medial longitudinal keel.

Dorsum light brown, central marking obsolete. Eye tubercle light brown in front, grey above. Venter considerably lighter than dorsum, being golden yellow. Trochanters and bases of femora brown on cephalic and caudal surfaces but much lighter on lateral surfaces and therefore not contrasting strongly with coxae. Legs nearly uniformly brown. Patella and apices of tibia somewhat darker than remainder of legs.

Female. Length, 7 mm. Length legs I, 28; II, 53; III, 28; IV, 39 mm.

Rows of tubercles on eye tubercle poorly developed. Abdomen rounded or pointed caudad. Genital operculum armed only with marginal rows of denticles. Femur of palpus extending only slightly above surface of carapace, armament similar in arrangement to that of male but composed of a smaller number of smaller tubercles.

Dorsum brown, central markings present but faint. Venter much lighter than dorsum being almost white.

Holotype ♂; allotype ♀. Tucson, Arizona, Cornell University collection.

Utah: Fillmore Canyon, 2♂, 3♀ (Chamberlin). *Arizona:* Tucson, August 12, 1932, 9♀, August 22, 1932. 1♂ (McCorkindale); Huachua, Nov. 1910, 2♀ (Wheeler). *New Mexico:* White Mountains, 1♂, 1♀.

Leiobunum ephippiatum Roewer

Leiobunum ephippiatum Roewer, Naturw. Ver. Hamburg Abh. 19(4):230. 1910.
Leiobunum ephippiatum Roewer, Weberknechte, p. 905. 1923.

Translation, Roewer "Die Weberknechte der Erde":

Male, Length 5 mm. Femora I - IV, 9; 14, 8, 11 mm.

Surface of carapace and of abdomen dorsally uniformly finely granulated. Eye tubercle above on either side of the shallow longitudinal median furrow with 4 to 6 teeth in each long row. Abdomen ventrally smooth. Surface of coxae I - IV roughly granulated. Coxae I - IV with an anterior and pos-

terior row of roundish denticles. Palpi unarmed. Legs: trochanters I - IV with teeth on either side. Femora I - IV with fine teeth in long rows. Patella and tibia similar.

Color of carapace grey-white, on lateral margin with fine dark brown curved line and sprinkled with brown on the surface in front of the eye on each side of the tubercle. Eye tubercle whitish grey, its median longitudinal furrow with a fine black line. A wide velvet brown central marking begins behind the eye tubercle, is constricted on the first abdominal tergite and runs from here parallel to the lateral margin as far as the fourth tergite where it widns on either side into a triangular broadening and from here gradually becomes smaller until it reaches the anal operculum; on the tergites it bears a transverse row of small but distinct spots. Abdomen on either side of the central marking whitish grey, here the tergites are streaked and spotted with brown. Abdomen ventrally and coxae I - IV grey white. Chelicerae and palpi uniformly light yellow. Legs: trochanters and bases of femora dark brown therefore contrasting strongly with coxae. Legs for remainder light yellow but patella and apices of tibiae darker brown.

Holotype ♂. Portland, Oregon. Collection Roewer.

Leiobunum exilipes (Wood)

Phalangium exilipes Wood, Essex Inst. Commun. 6:23, 39, f. 23. 1870.
Phalangium exilipes Underwood, Can. Ent. 17:168. 1885.
Leiobunum exilipes Weed, Am. Nat. 24:918. 1890.
Leiobunum exilipes Banks, Can. Ent. 26:162. 1894.
Leiobunum exilipes Banks, Am. Nat. 35:675. 1901.
Leiobunum exilipes Banks, Cal. Acad. Sci. Proc. 3(3):361. 1904.
Leiobunum exilipes Roewer, Naturw. Ver. Hamburg Abh. 19(4):216, 1910.
Leiobunum exilipes Banks, Pomona Jour. Ent. 3:421. 1911.
Leiobunum exilipes Comstock, Spider Book, p. 73. 1912.
Leiobunum exilipes Myers, Jour. Ent. & Zool. Claremont Cal. 13:19. 1921.
Leiobunum exilipes Roewer, Weberknechte p. 898. 1923.
Leiobunum exilipes Crosby and Bishop, Elisha Mitchell Sci. Soc. Jour. 40:13. 1924.

Male. Length 7 mm. Length legs I, 46; II, 80; III,49; IV, 49 mm.

Dorsum rather coarsely granulated; anterior margin of carapace armed with a patch of small black-tipped tubercles in the median line. Eye tubercle deeply canaliculate, granulated but not tuberculate. Abdomen subtruncate caudad. Venter: free sternites granulated but without tubercles. Genital operculum armed with numerous small black-tipped tubercles, marginal rows of denticles lacking. Coxae armed with numerous small black-tipped tubercles, marginal rows of denticles present only on anterior side of coxae I - III.

Palpus: femur of normal diameter, nearly straight, reaching above surface of carapace to a distance equal to one-half the height of the eye tubercle, armed laterally at distal and with an area of black tubercles which tapers towards the ventral side proximally, ventrolaterally with a row of larger tubercles, ventrally and mesally with numerous small black tubercles. Patella armed dorsally mesally and laterally with numerous small black tubercles. Tibia ventrally with these tubercles. Tarsus with mesoventral row of tubercles moderately well developed. Penis 3 mm, long, alate part 1 mm. long and extending to a point .5 mm from distal end. Shaft of penis a flat blade

with heavy scleritized lateral margins, shaft much broadened proximally, contacted in the middle and expanded distally, alate part very broad and usually tapered into the shaft distally. Dorsal grooves formed by upturned margins as mentioned by Wood in Comm. Essex Inst. v. VI, p. 24, not distinguishable in the specimens at hand. Two specimens have tiny vertical chitinized rods protruding from the alate part distally. Legs of moderate length and diameter.

Dorsum very dark or golden brown, a pair of longitudinal, light yellow, irregular bands running from the eye tubercle cephalad to the anterior margin and thence along the anterior margin to a point just caudad of the mesal surface of coxae I. Eye tubercle brown with darker bands around the eyes. Abdominal tergites each with a transverse row of conspicuous round yellow spots which are often placed at equal distances from one another so as to form longitudinal as well as transverse rows. Central marking obsolete. Venter: free sternites brown with yellow splotches. Genital operculum yellow. Coxae reddish yellow clouded with brown on the ventral surfaces. Palpus: femur with an area of yellow dorsolaterally on the proximal part, otherwise black. Patella black. Tibia very dark brown. Tarsus yellow. Legs: trochanters black. Femora black on bases, distad of these yellow then brown shading to a very dark brown distally. Remainder of legs very dark brown except tarsi which are ringed with light brown or yellow at the joints.

Female. Length, 8.5 mm. Length legs I,48; II, 74; III, 48; IV, 64 mm.

Marginal rows of tubercles lacking on coxae of one or two specimens at hand. Femur of palpus armed with tubercles on ventral side only. Patella of palpus with only a few scattered tubercles.

Light bands cephaled of eye tubercle with caudolateral extensions on either side of eye tubercle and much broader than in males.

Type, two ♂, one unknown, one coast of California, lat. 30 degrees, 33 minutes. Nevada.

Brit'sh Columbia: Inverness, July, 1 ♀ (Keen). *Vancouver:* 2 ♂, 1 ♀ (Banks).

Montana: 1 ♂ (Adams). *California:* Berkeley, Oct. 1919, 1 ♂, 2 ♂, 1 ♀, 1 imm. (Bradley); Santa Clara, 1 ♂, 2♀, 2 imm. (Baker); Claremont, 5 imm. (Chamberlin); Los Angeles, 6 imm. (Banks); Palo Alto, 3 ♂, 1 ♀ (Banks); Swanton, Nov. 29, 1932, 1 ♀ (Needham) Paradise Park, Mt. Ranier, July 20, 1905, 1 ♂.

Leiobunum flavum Banks

Leiobunum flavum Banks, Can. Ent. 26:164. 1894.
Leiobunum flavum Banks, Acad. Nat. Sci. Phila. Proc. 52:541. 1900.
Leiobunum flavum Banks, Am. Nat. 35:676. 1901.
Leiobunum flavum Roewer, Naturw. Ver. Hamburg Abh. 19(4):227, pl. 5, f. 15. 1910.
Leiobunum flavum Banks, Phila. Acad. Nat. Sci. Proc. 63:456. 1911.
Leiobunum flavum Comstock, Spider Book, p. 73. 1912.
Leiobunum flavum Roewer, Weberknechte, p. 904. 1923.
Leiobunum flavum Crosby and Bishop, Elisha Mitchell Sci. Soc. Jour. 40:13, 20. 1924.
Leiobunum flavum Walker, Ohio Biol. Surv. Bul. 19:164, pl. 3, f. 22. 1928.

Male. Average length 6.5 mm. Average length legs I, 45; II, 86, III,

46; IV, 55 mm. (Southern specimens). Average length 6 mm. Average length legs I, 25; II, 47; III, 25; IV, 36. (Northern specimens).

Dorsum finely granulated, a few golden tubercles on anterior margin of carapace. Eye tubercle very shallowly canaliculate, with well developed rows of tubercles over each carina. Abdomen truncate or subtruncate caudad. Venter: free sternites armed with a few scattered tubercles. Genital operculum with a number of these tubercles, marginal rows of denticles well developed. Coxae thickly set with tubercles, marginal rows of denticles present.

Palpus: femur slender, nearly straight, extending above surface of carapace a distance equal to one-half the height of the eye tubercle, armed ventrally with numerous tubercles, laterally with a group of tubercles on distal end which is often continued proximally narrowing into a row, dorsally and mesally with a few tubercles on distal part. Patella armed dorsally and on sides with a few tubercles. Tibia with only hairs or with a few tubercles ventrally. Tarsus covered with dark hairs, mesoventral row of tubercles distinct. Legs fairly long and moderately robust.

Dorsum golden to golden-brown, central marking subobsolete. Eye tubercle brown with a dark ring around each eye, sometimes darker dorsally. Venter concolorous with or a little lighter than dorsum. Palpus and legs (excepting coxae) concolorous with dorsum.

Two forms of this species occur which may be separated by the following key:

Alate part of penis entirely lacking ..... *L. f. leiopenis*
Alate part of penis present and distinct ..... *L. f. flavum*

Leiobunum flavum flavum Banks

Femur of palpus with a prominent mesoproximal row of tubercles. Penis 4.6 mm. long, alate part 1 mm. long and extends to a point .5 mm. from distal end. Proximal part of penis a flat blade with heavily scleritized lateral margins. Tip of penis compressed laterally and curved dorsally.

Leiobunum flavum leiopenis subsp. nov.

Femur of palpus with numerous tubercles ventromesally but without a distinct proximesal row. Penis 3.2 mm. long, in the form of a long flat blade with heavy scleritized lateral margins which tapers distally to a tip shaped as a spear-head.

Female, length of body 10 mm. Length of legs, I, 44; II, 85; III, 41, IV, 62 mm. (Florida specimen). Length of body 9 mm. Length of legs I, 27; II, 47; III, 27; IV, 40 mm. (Specimens from Long Island, N. Y.).

Rows of tubercles over each carina sometimes poorly developed. Abdomen usually caudad, sometimes rather pointed. Femur of palpus shorter than in male extending only slightly above surface of carapace. Armature of palpus similar in arrangement to that of male but lighter.

Dorsum golden-brown, noticeably darker than venter, central markings faint but usually discernable at least immediately caudad of eye tubercle.

Female of this species are difficult to differentiate from those of *L. ven-*

tricosum. However, *L. ventricosum* can usually be recognized by its pointed abdomen.

Type, ♂. Shreveport, Louisiana, collection Harvard Museum of Comparative Zoology.

Massachusetts: Woods Hole, July, 1 ♂. *New York:* Montauk, June 20, 1927, 4 ♀, 1 ♀ (Latham). *Oklahoma:* Wichita National Forest, Sept. 1, 1930, 1 ♂, 1 ♀ (Hubbell). *Missouri:* Waynesville, August 20, 1929, 1 ♂ (Williamson); Columbia, June, 2 imm.; Hollister, August 10, 1912, 1 ♂, 1 ♀; Columbia, 1 ♂ (Crosby). *Tennessee:* Fulton, August 10, 1929, 2 ♂, 7 ♀ (Hubbell); Obion, August 11, 1929, 2 ♂, 2 ♀ (Hubbell). *New Mexico:* Los cruces, 1 ♂. *Texas:* San Antonio, 1 ♂, 2 ♀ (Banks); Victoria, August 1905, 1 ♂ (Mitchell); Houston, August 1932, 1 ♂, 3 ♀ (Harwood). *Louisiana:* Chastine, May 12, 1 ♂ (Schmidt). *Mississippi:* Lucedale, Sept. 1931, 1 ♂ (Dietrich); Jackson, August 17, 1929 (Hubbell). *Alabama:* Talladega, August 24, 1929, 1 ♂, 1 ♀ (Hubbell). *Florida:* Mariana, July 25, 1930, 2 ♂.

Leiobunum formosum (Wood)

Phalangium formosum Wood, Essex Inst. Commun. 6:30, 40, f. 1870.
Phalangium formosum Underwood, Can. Ent. 27:168. 1885.
Leiobunum formosum Weed, Ill. State Lab. Nat. Hist. Bul. 3:83, 91, 103, f. 1889.
Forbesium formosum Weed, Am. Nat. 24:918, pl. 30. 1890.
Leiobunum ventricosum Weed, U. S. Nat. Mus. 16:551, Pl. 63. 1893.
Leiobunum formosum Banks, N. Y. Ent. Soc. Jour. 2:145. 1894.
Leiobunum formosum Banks, Am. Nat. 35:676. 1901.
Leiobunum formosum Banks, N. Y. Ent. Soc. Jour. 12:256. 1904.
Leiobunum formosum Banks, Boston Soc. Nat. Hist. Occasional Papers, 7(10):1. 1908.
Leiobunum formosum Roewer, Naturw. Ver. Hamburg Abh. 19(4):214. 1910.
Leiobunum formosum Comstock, Spider Book, p. 73. 1912.
Leiobunum formosum Roewer, Weberknechte, p. 897. 1923.
Leiobunum formosum Crosby and Bishop, Elisha Mitchell Sci. Soc. Jour. 40:13. 1924.
Leiobunum formosum Crosby and Bishop, Cornell Univ. Agr. Exp. Sta. Mem. 101:1075. 1928.
Leiobunum formosum Walker, Ohio Biol. Surv. Bul. 19:164, pl. 1, f. 7. 1928.

Male. Average length, 7.8 mm. Average length legs I, 57; II, 110, III, 57; IV, 76 mm. (Florida specimens). Average length 6.5 mm. Length of legs I, 42; II, 78; III, 42; IV, 60 mm. (Northern specimens).

Dorsum smoothly granulated. A few scattered black-tipped tubercles along anterior and lateral margins of carapace. Eye tubercle low rounded not canaliculate, unarmed or with one to four stumpy tubercles over each carina. Abdomen bluntly rounded caudad. Venter: free sternites unarmed or with a very few tiny golden tubercles. Tubercles larger and more numerous on genital operculum, marginal rows of denticles well developed. Coxae with anterior rows of marginal denticles well developed; posterior rows on coxae I - III poorly developed, or lacking. Palpus: femur slightly curved distally, extending above surface of carapace to about one-half height of eye tubercle, armed dorsally on distal end with a scattering of well developed black-tipped tubercles; armed ventrally with two, thickly set, irregular, longitudinal rows of tubercles. Patella armed dorsally with numerous well developed black tubercles. A ring of tubercles around distal margin. Mesodistal margin sometimes with a slight swelling which is thickly set with hairs. Tibia

armed with a few black-tipped tubercles laterally, and often also ventrally, on distal margin. Tarsus thickly set with brown hairs; mesoventral row of tubercles well developed. Penis a flat blade 3.2 mm. long, tapering distally to a tip shaped as a spear-head. Lateral margins of penis heavily scleritized. Legs moderately slender.

Dorsum a uniform orange-yellow, eye tubercle very dark brown or black. Central marking obsolete. Venter very slightly lighter than dorsum. Coxae faintly darker than venter, due perhaps to the numerous tubercles. Chelicera yellow. Palpus: femur yellow, marked distally with black or brown. Patella black or brown. Tibia and tarsus yellow. Trochanters and bases of femora black, contrasting strongly with coxae. Legs yellowish with black markings at joints, sometimes entirely infuscate.

This species is easily confused with *L. nigripes* when the dark bands on legs are not distinct but may be readily distinguished from the latter by the form of the penis.

Female. Average length 10.5 mm. Average length of legs I, 52; II, 115, III, 52; IV, 72 mm. (Florida specimens). Average length 10 mm. Length of legs I, 32; II, 70; III, 32; IV, 48 mm. (Northern specimens).

Dorsum of female darker than that of male being considerable darker than venter.

Females of this species are very similar to those of *L. nigripes*. They can usually be differentiated by the presence of dark brown or black annulations on the legs.

Types ♀. Type locality, Philadelphia, Pennsylvania and District of Columbia.

Ohio: Hocking Co., Sept. 10, 1931, 4 ♂, 3 ♀, (Hubbell). *New Jersey:* Atlantic Co., August 12, 1929, 5 ♂, 7 ♀. *Kentucky:* Bee Springs, 1 ♀, 7 imm. *South Carolina:* Greenwood, Oct. 5, 1930, 1 ♂, 2 ♀. *Florida:* Marianna, April 13, 1930, 8 ♂ and ♀ (Zeigler), July 24, 1930, 5 ♂; Chattahoochie, July 24, 1930, 8 ♂, June 11, 1930, 1 ♂ (Van Hyning); Liberty Co., July 19, 1930, 12 ♂, 9 ♀, May 27, 1931, 28 imm.

Leiobunum longipes Weed

Leiobunum nigropalpi Weed, Am. Nat. 21:935. 1887.
Leiobunum nigropalpi Weed, Ill. State Lab. Nat. Hist. Bul. 3:82, 87. 1889.
Leiobunum longipes Weed, Am. Nat. 24:866, pl. 29. 1890.
Leiobunum longipes Weed, Am. Ent. Soc. Trans. 19:265, pl. 14, f. 1. 1892.
Leiobunum longipes aldrichi Weed, Am. Ent. Soc. Trans. 20:289. 1893.
Leiobunum longipes Weed, U. S. Nat. Mus. Proc. 16:550, pl. 62, f. 1. 1893.
Leiobunum longipes Banks, N. Y. Ent. Soc. Jour. 2(4):145. 1894.
Leiobunum longipes Banks, Am. Nat. 35:676. 1901.
Leiobunum longipes Banks, Ent. News 13:309. 1902.
Leiobunum longipes Banks, N. Y. Ent. Soc. Jour. 12:256. 1904.
Leiobunum longipes Banks, Boston Soc. Nat. Hist. Occasional Papers 7(10):1. 1908.
Leiobunum longipes Roewer, Naturw. Ver. Hamburg Abh. 19(4):224, pl. 6, f. 11. 1910.
Leiobunum longipes Comstock, Spider Book, p. 73. 1912.
Leiobunum longipes Roewer, Weberknechte, p. 902. 1923.
Leiobunum longipes Crosby and Bishop, Elisha Mitchell Sci. Soc. Jour. 40:13, 21. 1924.
Leiobunum longipes Walker, Ohio Biol. Surv. Bul. 19:164, pl. 1. f. 3. 1928.

Male. Average length 3.5 mm. Average length of legs I, 45; II, 90; III, 48; IV, 62 mm. (Length of legs varies greatly in this species.)

Dorsum finely granulated, anterior margin of carapace usually unarmed, sometimes with two to four small tubercles in median line. Eye tubercle high, constricted basally, deeply canaliculate, well armed with sturdy black tubercles over each carina. Abdomen subtruncate caudad. Venter: free sternites unarmed. Coxae with a few low tubercles, marginal rows of denticles present but small on anterior side of coxae I - IV and on the posterior side of coxa IV, usually lacking on posterior side of coxae I - III. Genital operculum armed only with marginal rows of denticles.

Palpus: femur slender, nearly straight, extending above surface of carapace about three-fourths of the height of eye tubercle; armed distally on both sides and on distodorsal surface with small tubercles, armed ventrally with a number of tubercles arranged roughly in two rows. Patella armed dorsally and on both sides with dark brown tubercles, distal ring of tubercles usually incomplete, ventrally unarmed. Tibia armed with numerous hairs and a few scattered tubercles. Tarsus armed with hairs, mesoventral row of tubercles distinct. Penis 2.3 mm. long, alate part 8 mm. long and extending to a point .4 mm. from distal end. Proximal part of penis a flat blade with heavily scleritized margins, lightly compressed approximately midway of its length then again expanded. Legs very long and very slender.

Dorsum golden yellow. Central marking obsolete (in young specimens subobsolete). Eye tubercle black. Venter a little lighter than dorsum, coxae often a little darker than rest of venter. Palpus yellow, distal end of femur and patella often darker. Trochanters very dark brown or black, contrasting strongly with coxae and dorsum. Legs very dark brown or black, apex of second tibia with a broad white band.

Female. Average length 6 mm. Average length of legs I, 32; II, 65; III, 32; IV, 45 mm.

Anterior margin of carapace unarmed. Abdomen rounded caudad. Femur of palpus extending above surface of carapace one-half height of eye tubercle, armed only with hairs except for a few tubercles distoventrally. Patella and tibia of tarsus with a few tubercles and numerous hairs.

Dorsum brown, central marking distinct and outlined by a lighter area. Margins of dorsum brown except cephalically on certain specimens where it is whitish. Venter whitish contrasting with dorsum. Legs usually brown, apex of second tibia banded with white as in male.

This species was divided into two subspecies by Weed as follows:

Leg II less than 70 mm. long, margins of carapace black_____*L. l. aldrichi*
Leg II more than 70 mm. long, margins of carapace not black_____*L. l. longipes*

Types numerous ♂, southern Illinois.

Maine: Warwick, 2 ♂. *Michigan:* Douglas Lake, July 19, 1922, 1 ♂; Milford, Sept. 2, 1930, 1 ♀ (Hubbell); Huron Co., July 22, 1931, 60 specimens (Hubbell). *Illinois:* Chicago, 1 ♀ (Mortimer). *Indiana:* Madison, Sept. 6, 1930, 3 ♂ (Hubbell); Salt Petre Cave, 1 ♂. *Ohio:* Buckeye Lake, 1 ♀, 1 ♂ (Walker); Starke Co., July 24, 1930, 15 ♂, 3 ♀ (Stahl). *New York:* Fairhaven, July 31, 1932, 11 ♂ (Hughes); Rhinebeck, July 29, 1927, 2 ♂; Penn Yan, August 2, 1925, 4 ♂, 1 female (Crosby); Aug. 29, 1926, 1 ♂, 1 ♀; Lake George, August 1920,

1 ♀; Plattsburg, Sept. 5, 1910, 3 ♂; Stow, Sept. 17, 1925, 1 ♂; Barcelona, Sept., 1925, 1 ♂; Ausable Chasm, Sept. 6, 1925, 1 ♂ (Leonard); Hague, Sept. 15, 1925, 1 ♂ (Leonard); Silver Creek, Sept. 18, 1925, 1 ♂; Wilmington, Aug. 22, 1916, 1 ♂ (Bailey); Wellsville, Sept. 15, 1925, 1 ♂; Thousand Islands 1 ♂; many specimens, vicinity Ithaca. *Pennsylvania:* Orangeville, Aug. 10, 1932, 38 ♂, 11 ♀ (Hughes); Hazleton, 1925, 3 ♀ (Deitz); Lehighton, 1 ♀. *West Virginia:* Williamsport, 2 ♂; Harpers Ferry, 2 ♀ (Banks). *Washington, D. C.:* 2 ♂. *Virginia:* Pennington Gap, 1 ♂; Great Falls, Sept. 16, 1 ♂; Falls Church, Oct. 19, 5 ♂ (Banks). *Missouri:* Rockport Cave, Nov. 6, 1904, 1 ♀. *Arkansas:* 2 ♂ (Chamberlin). *Kentucky:* Quicksand, Aug., 1925, 1 ♂ (Funkhauser); Brooklyn Bridge, June 29, 1925, 5 ♂, 3 ♀; Mammoth Cave, July 1, 1925, 2 ♂, 1 ♀; Bee Springs, June 8, 1 ♂ (Sanborn). *Tennessee:* Laurel Creek, Oct. 8, 1926, 1 ♂; Lookout Mountain, 1 ♀. *North Carolina:* Owens Gap, Aug. 28, 1 ♂ (Banks); Winston-Salem, Oct. 28, 1923, 1 ♀. *Georgia:* Tallulah Falls, June 17, 1910, 1 ♀.

Leiobunum nigripes Weed

Leiobunum verrucosum Weed, Am. Nat. 21:935. 1887.
Leiobunum verrucosum Weed, Ill. State Lab. Nat. Hist. Bul. 3:88. 1889.
Leiobunum verrucosum Weed, Am. Nat. 24:918. 1890.
Leiobunum nigripes Weed, Am. Ent. Soc. Trans. 19:190, pl. 7, 1892.
Leiobunum nigripes Weed, U. S. Nat. Mus. Proc. 16:547, pl. 60. 1893.
Leiobunum nigripes Weed, Life Hist. of Am. Insects, p. 263 f. 94. 1897.
Leiobunum nigripes Banks, Am. Nat. 35: 676. 1901.
Leiobunum nigripes Roewer, Naturw. Ver. Hamburg Abh. 19(4):220. 1910.
Leiobunum nigripes Comstock, Spider Book, p. 73. 1912.
Leiobunum nigripes Roewer, Weberknechte, p. 900. 1923.
Leiobunum nigripes Crosby and Bishop, Elisha Mitchell Sci. Soc. Jour. 40:13. 1924.
Leiobunum nigripes Walker, Ohio Biol. Surv. Bul. 19:164, pl. 2, f. 13. 1928.

Male. Average length 6 mm. Average length of legs I, 27; II, 50; III, 27; IV, 38 mm. (Northern specimens). Average length 7 mm.; average length of legs I, 51; II, 100; III, 51; IV, 72 mm. (Florida specimens).

Dorsum: anterior margin of carapace armed with a few tubercles, remainder of dorsum granulate. Eye tubercle as high as wide, very slightly canaliculate and armed with a few black tubercles. Abdomen subtruncate behind. Venter: free sternites armed with very small tubercles. Genital operculum and coxae strongly tuberculate. Marginal rows of wedge-shaped denticles well developed on anterior side of coxae 1 - IV, weakly developed on genital operculum and weakly developed or lacking on posterior side of coxae 1 - III.

Palpus: femur slender, slightly arched distally extending above surface of carapace one-half height of eye tubercle; armed dorsally with a few scattered black-tipped tubercles at distal end; armed ventrally with two distinct rows as well as a number of scattered black-tipped tubercles. Patella armed dorsally and ventrally with scattered black-tipped tubercles; a ring of these around distal margin. Tibia armed only with hairs or with hairs and a very few tubercles. Tarsus covered with hairs; mesoventral row of tubercles well developed. Penis 3.7 mm. long (Florida specimens 4.1 mm. long), alate part 1.3 mm. long and reaching to a point .5 mm. from distal end. Proximal part of penis a flat blade with heavily scleritized lateral margins; this blade expanded slightly in the middle of the alate part (this character most noticeable in northern specimens), strongly compressed and bent dorsally towards tip.

Dorsum a uniform orange-yellow, eye tubercle very dark brown or black. Central marking obsolete. Venter very slightly lighter than dorsum. Coxae faintly darker than venter, due perhaps to numerous tubercles. Palpus a golden yellow, patella dorsally and femur distodorsally mottled with very dark brown or black. Trochanters black, contrasting strongly with coxae. Legs dark brown to black, sometimes with darker annulations at joints as in *L. formosum*, but not as distinct.

Young adults of this species have a brown dorsum and a yellowish white venter which makes them readily confused with *L. verrucosum*. The legs, however, are not shaded distally in *L. nigripes*. Specimens from Michigan have dark brown trochanters and brown legs giving them a superficial resemblance to *L. flavum*. They may be distinguished from the latter by the poorly developed armament of the tye tubercle and by their extreme shortness of legs (I, 20; II, 35; III, 20; IV, 26). Female *L. nigripes* are more distinct because of the dark brown coloration of the dorsum.

Female. Average length 8 mm. Length of legs I, 29; II, 48; III, 29; IV, 42 mm. (Northen specimens except those from Michigan). Length, 8.5 mm. Length legs I, 20; II, 35; III, 20; IV, 30; mm. (Michigan specimens). Average length 9.5 mm. Average length of legs I, 46; II, 91; III, 46; IV, 62 mm. (Florida specimens).

Abdomen rounded caudad. Femur of palpus shorter than in male extending above carapace a distance equal to one-fourth height of eye tubercle.

Dorsum dark brown. Eye tubercle dark brown. Central marking visible, sometimes faint. Free sternites yellowish contrasting with dorsum. Coxae usually slightly darker than sternites. Trochanters and bases of femora a black or very dark brown. Rest of legs dark brown.

Types, numerous ♂ and ♀. Champaign Co., Illinois; Clermont, Franklin, and Warren Counties, Ohio.

New York: Montauk, June 25, 1927, 1 ♂; Sea Cliff, 1 ♂, 6 ♀ (Banks); Manorville, Sept. 15, 1928, 1 ♀ (Lathan); Greenport, Jan. 10. 1928, 1 ♀ (Lathan). *Ohio:* Columbus, 4 ♂, (Walker); Buckeye Lake, 4 ♂, 2 ♀ (Walker). *Pennsylvania:* Philadelphia, 1 ♂ (Banks). *New Jersey:* Atlantic Co., Aug. 10, 1929, 10 ♂, 7 ♀, Aug. 6, 1931, 1 ♂, 1 ♀, Sept. 2, 1931, 2 ♂, 2 ♀. *Kentucky:* Bee Springs, 2 ♂, 1 ♀ (Sanford). *Virginia:* Great Falls, 3 ♂, (Banks); Chain Bridge, 1 ♂ (Banks). *Arkansas:* Oseola, Aug. 12, 1929, 1 ♂, 10 ♀ (Hubbell). *Tennessee:* Obion, Aug. 11, 1929, 11 ♂, 15 ♀ (Hubbell); South Fulton, Aug. 10, 1929, 40 ♂, 40 ♀ (Hubbell); Reelton Lake, Aug. 11, 1929, 1 ♂, 1 ♀ (Hubbell). *Georgia:* Atlanta, July 10, 1 ♂ (Bradley). *Florida:* Liberty Co., Sept. 11, 1930, 1 ♀ (Hubbell); July 19, 1930, 6 ♂, 2 ♀, May 29, 1931, 4 ♂, 3 ♀; Gadsden Co., June 12, 1930, 1 ♂ (Van Hyning); Chattahootchee, July 24, 1930, 10 ♂, 2 ♀; Marianna, July 24, 1930, 2 ♂.

Leiobunum nigropalpi (Wood)

Phalangium nigropalpi Wood, Essex Inst. Commun. 6:22, 39, f. 3. 1870.
Phalangium nigropalpi Underwood, Can. Ent. 17:168. 1885.
Leiobunum nigropalpi Weed, Ill. State Lab. Nat. Hist. Bul. 3:101. 1889.
Leiobunum nigropalpi Weed, Am. Nat. 24:918. 1890.
Leiobunum nigropalpi Weed, Am. Ent. Soc. Trans. 19:187, pl. 4. 1893.
Leiobunum nigropalpi Weed, U. S. Nat. Mus. 16:547, pl. 59. 1893.
Leiobunum nigropalpi Banks, Am. Nat. 35:675. 1901.
Leiobunum nigropalpi Roewer, Naturw. Ver. Hamburg Abh. 19(4):213. 1923.

Leiobunum nigropalpi Comstock, Spider Book, p. 73. 1912.
Leiobunum nigropalpi Roewer, Weberknechte, p. 896. 1923.
Leiobunum nigropalpi Crosby and Bishop, Elisha Mitchell Sci. Soc. Jour. 40:13, 21. 1924.
Leiobunum nigropalpi Crosby and Bishop, Cornell Agr. Exp. Sta. Mem. 101:1075. 1928.
Leiobunum nigropalpi Walker, Ohio Biol. Surv. Bul. 19:163, pl. 2, f. 14. 1928.

Male. Average length 6 mm. Average length of legs I, 38; II, 72; III, 39; IV, 56.

Dorsum finely granulated, anterior margin without tubercles. Eye tubercle deeply canaliculate, rows of tubercles over carina present but often poorly developed. Abdomen pointed caudad. Venter: free sternites smooth or with fine granulations, no tubercles present. Genital operculum smooth or with very fine granulations, marginal rows of denticles present but small. Coxae smooth, posterior marginal rows of denticles poorly developed or lacking on coxae I - III, anterior rows of denticles on coxae I - IV and posterior row on coxa IV distinct.

Palpus: femur proximally slender slightly thickened and curved; extending above the surface of carapace a distance equal to 1.5 times the height of the eye tubercle; armed dorsally on distal end with a few small black tubercles, a row of larger tubercles ventrolaterally. Patella with mesodistal margin swollen, armed with small tubercles dorsally and laterally. Tibia bent dorsally, armed with a few scattered tubercles ventrally on the proximal part and a short row of tubercles ventromesally. Tarsus armed with a well developed row of tubercles mesoventrally. Penis 4 mm. long, shaft of penis a long flat blade with heavily scleritized margins only on distal portion which tapers gradually to the tip which is lightly expanded and bent dorsally. Legs of moderate length and diameter.

Dorsum golden-yellow to light red-brown. Eye tubercle dark brown. Central marking indistinct or subobsolete. Venter slightly lighter than dorsum. Palpus: femur proximally yellow, distally black. Patella black. Tibia dark brown. Tarsus proximally clouded with brown, distally yellow. Brown on tarsus sometimes lacking. Legs: trochanters and proximal portions of femora brown, dark brown, or black, contrasting although sometimes weakly with coxae, remainder of legs light to dark brown.

Female. Average length 7 mm. Average length legs I, 33; II, 65; III, 33; IV, 48 mm.

Abdomen pointed or rounded caudad. Femur of palpus extending above surface of carapace about three-fourths the height of the eye tubercle, nearly straight and only very slightly thickened distally, armed similarly but more lightly that that of the male. Ventromesal row of tubercles on tibia lacking.

Dorsum brown mottled with light brown. Central marking distinct. Venter yellow contrasting with dorsum. Distal end of femur and patella of palpus brown. Tibia light brown and tarsus of palpus yellow. Trochanters and bases of femora of legs brown, remainder of legs light brown.

Types, numerous ♂ and ♀. Huntingdon Co., Pennsylvania.

Michigan: Huron Co., July 22, 1931, 14 ♂, 2 ♀ (Hubbell). *Illinois:* Chicago, 1 ♂ (Banks). *Ohio:* Starke Co., July 24, 1930, 1 ♂ (Stahl); Buckeye Lake,

4 ♂ (Walker). *New York:* Fairhaven, July 31, 1932, 10 ♂ (Hughes); Hemlock Lake, Aug., 1911, 1 ♂; Lake Verona, June 16, 1925, 4 ♂, 1 ♀ (Dietz); Caldwell, June 17, 1925, 3 ♂ (Dietz); neighborhood of Ithaca, numerous specimens. *Pennsylvania:* Orangeville, Aug. 6, 1932, 27 ♂, 9 ♀ (Hughes); Hazleton, 1925, 1 ♂, 2♀ (Dietz); Sunbury, July, 4 ♂, 1 ♀ (Shaler); Cumberland Valley Aug., 5 ♂, 1 ♀; Lehighton, 3 ♂, 3 ♀. *Georgia:* Tallulah Falls, 1 ♂ (Bradley).

Leiobunum paessleri Roewer

Leiobunum paessleri Roewer, Naturw. Ver. Hamburg Abh. 19(4):215, pl. 6, f. 16. 1910.

Leiobunum paessleri Roewer, Weberknechte, p. 897, f. 1053. 1923.

Male. Length, 4 mm. (Measurements from Roewer "Die Weberknechte" p. 897. Length body 4; femora I - IV, 6.5; 10.5; 6.5; Legs 1 - IV, 37; 58; 37; 47 mm.)

Dorsum finely granulated, anterior margin without tubercles. Eye tubercle deeply canaliculate, rows of tubercles over carina lacking. Abdomen subtruncate caudad. Venter: free sternites finely granulated. Genital operculum finely granulated, marginal rows of denticles lacking. Coxae with numerous tiny tubercles, marginal rows of denticles subobsolete, visible only in traces. (Roewer describes these denticles as being present on both anterior and posterior sides.)

Palpus: femur of normal diameter, nearly straight, extending above surface of carapace to a distance equal to the height of the eye tubercle; armed laterally on distal end with a number of sturdy black tubercles, ventrally and mesally with these tubercles throughout entire length. Patella armed laterally, dorsally, and mesally with small black tubercles. Tibia straight, armed with a few tubercles ventrally. Tarsus with mesoventral row of tubercles poorly developed. Penis 1.9 mm. long, alate part not as wide as blade and therefore not visible in dorsal view. Shaft of penis a wide flat blade slightly broadened proximally and distally. Distally this blade is truncated the tip protruding from the truncated end of the blade. Legs of moderate diameter.

Dorsum golden-brown to dark brown, very much mottled; central marking present or central marking obsolete but free tergites with transverse golden markings in median line. Eye tubercle light brown with darker rings around the eyes. Venter: free sternites light yellow, coxae golden-yellow banded with light brown distally. Palpus: femur yellow on proximal extremity, distally black. Patella black. Tibia very dark brown. Tarsus proximally clouded with dark brown, distally yellow. Legs: trochanters and bases of femora light yellow, remainder of legs black or dark brown with light annulations on apices of metatarsi and articulations of tarsi. Sometimes with annulations on apices of remaining segments.

Female. Length 7 mm. Length of legs I, 32; II, 54; III, 35; IV, ?? mm.

Abdomen rounded caudad. Femur of palpus extending only a very slight distance above surface of carapace. Palpus with dark brown instead of black marking as in male. Legs usually lighter than male.

Holotype, ♂. Port Ludlow, Puget Sound, Collection Roewer.

Alaska: Adm. Id., June 20, 1932, 1 ♂ (Hasselborg); Goose Bay, June 1918 (Hine). *British Columbia:* Rogers Pass, Aug., 1908, 1 ♂, 1 ♀ (Bradley); Met-

takatle, July - Oct., 2 ♂, 1 ♀ (Keen). *Washington:* Olympia, 8 ♂, 3 ♀ (Banks); Blewitt, May 27, 1929, 1 ♀, 1 imm. (Leonard); Lake Sutherland, Aug. 11, 1927, 1 ♀. *Oregon:* Hood River, June 19, 1929, 1 ♂, 1 ♀, imm. *California:* Giant Forest, July 21, 1907, 1 ♂, 1 ♀.

Leiobunum peninsulare sp. nov.

Male. Average length 4 mm. Average length of legs, I, 44; II, 87; III, 45; IV, 62 mm.

Dorsum granulated. A few small tubercles sometimes in median line at cephalic margin. Eye tubercle high, armed with 3 - 5 tubercles over each carina, not canaliculate. Fused abdominal tergites with scattered brown tubercles along lateral margins, particularly near caudal margin. Abdomen subtruncate caudad as seen from above. Free sternites armed with transverse rows of silver-yellow tubercles. Marginal rows of wedge-like denticles entirely lacking, genital operculum otherwise well armed with silver-yellow tubercles. Coxae with numerous silver-yellow tubercles; marginal rows of wedge-like denticles well developed on anterior side of coxae I - IV and on posterior side of coxa IV; posterior row incomplete or lacking on coxae I - III.

Palpus: femur slender, straight, extending little if any above surface of carapace; armed distodorsally with a few small brownish tubercles, ventrally with numerous scattered silver-yellow tubercles. Patella armed dorsally with brownish tubercles, a ring of these around distal margin, ventrally with only a few yellow hairs. Tibia well armed on all sides with brownish tubercles; a ring of these around distal end. Tarsus covered with yellow hairs, mesoventral row of tubercles poorly developed, frequently reduced to a few tubercles on proximal portion or entirely lacking. Penis 2.8 - 3 mm. long, alate part .6 mm. long and extends to a point .5 mm. from distal end. Proximal part of penis a flat blade with heavily scleritized lateral margins; this blade lightly compressed laterally at base of alate part, then expanded, then terminating in a tip which is very strongly compressed laterally and is bent dorsally. Legs moderately slender.

Dorsum dark brown, without any white markings. Eye tubercle pale in front, darker above. Central marking usually subobsolete sometimes outlined by a lighter stripe along edges. Venter silver-yellow, abdomen and coxae concolorous. Palpus yellow-brown. Trochanters and extreme bases of femora light brown, contrasting slightly with coxae but not darker than dorsum. Proximal portions of legs except extreme bases of femora yellowish; legs shading to a darker brown distally.

Female. Average length, 6.5 mm. Average length of legs I, 43; II, 82; III, 43; IV, 61 mm.

Abdomen rounded caudad as seen from above. Tibia of palpus lacking ring of tubercles on distal end. General coloration same as in male.

Immatures of this species sometimes show lateral markings on the dorsum near the union of the carapace and abdomen similar to those found on *L. bimaculatum*. These are light brown rather than white and have never been observed in mature specimens. It is possible that this species is in reality a southern form of *L. bimaculatum*.

Holotype, ♂. Homestead, Florida. Allotype ♀, Arcadia, Florida. Cornell collection.

Florida: Volusia Co., May 23, 1931, 4 ♂; Polk Co., Oct. 15, 1930, 1 ♂ (Zeigler); Pinellas Co., Dec. 15, 1926 1 ♂ (Blatchley); Sept. 3, 1930, 1 ♂ (Zeigler); Sebastian, 2 ♂ (Kroegal); Orlando, May 19, 1926, 1 ♂; Okeechobee, May 24, 1931, 1 ♂ (Hubbell); Manatee, Apr. 21, 1927, 6 imm. (Leonard); Sarasota Co., Aug. 14, 1910, 8 ♂, 1 ♀ (Bradley); Hastings, Oct. 25, 1926, 1 ♀ (Leonard); Arcadia, Nov. 27, 1930, 1 ♀ (Platt), 1 ♂ (Hollingsworth); Homestead, Aug. 12, 1930, 1 ♂ (Van Hyning).

Leiobunum politum Weed

Leiobunum politus Weed, Ill. State Lab. Nat. Hist. Bul. 3:82, 89, 102. 1889.
Leiobunum politus Weed, Am. Nat. 24:918. 1890.
Leiobunum politum Weed, Am. Nat. 25:295, pl. 9. 1891.
Leiobunum politum Weed, Am. Ent. Soc. Trans. 19:266, pl. 15. 1892.
Leiobunum politum Weed, U. S. Nat. Mus. Proc. 16:548, pl. 61. 1893.
Leiobunum politum magnum Weed, Psyche 6:428, pl. 15. 1893.
Leiobunum politum Weed, Life Hist. Am. Insects. p. 261, f. 93. 1897.
Leiobunum politum Banks, Am. Nat. 35:676. 1901.
Leiobunum politum Banks, N. Y. Ent. Soc. Jour. 12:256. 1904.
Leiobunum politum Banks, Boston Soc. Nat. Hist. Occasional Papers, 7(10):1. 1908.
Leiobunum politum Roewer, Naturw. Ver. Hamburg Abh. 19(4):219. 1910.
Leiobunum politum Comstock, Spider Book, p. 73. 1912.
Leiobunum politum Roewer, Weberknechte, p. 899. 1923.
Leiobunum politum Crosby and Bishop, Elisha Mitchell Sci. Soc. Jour. 40:13, 21. 1924.
Leiobunum politum Crosby and Bishop, Cornell Agr. Exp. Sta. Mem. 101:1075. 1928.
Leiobunum politum Walker, Ohio Biol. Surv. Bul. 19:165, pl. 1, f. 5. 1928.

Male. Average length 4.8 mm.; average length of legs I, 40; II, 84; III, 43; IV, 59 mm. (Florida specimens). Average length 4.5 mm.; average length of legs I, 24; II, 47; III, 25; IV, 35 mm. (Northern specimens).

Dorsum finely granulated, no tubercles present on cephalic margin of carapace. Eye tubercle high, constricted basally, deeply canaliculate, well armed with sturdy black-tipped tubercles over each carina. Abdomen usually rounded or subtruncate, sometimes rather pointed caudad. Venter: free sternites unarmed. Coxae of northern specimens smooth or armed only with a few poorly developed tubercles, marginal rows of denticles obsolete or subobsolete; coxae of southern specimens armed with a few low tubercles, marginal rows of denticles distinct on anterior surface of coxae 1 - IV, lacking on posterior surface of coxae I and II, poorly developed or lacking on posterior surface of coxae III and IV. Genital operculum smooth in northern specimens, armed with low tubercles and marginal rows of denticles in southern specimens.

Palpus: femur moderately slender, nearly straight, extending above surface of carapace a distance equal to the height of the eye tubercle; armed distodorsally and distolaterally with a few tubercles, armed only with hairs ventrally. Patella armed dorsally and laterally with a number of tubercles; distal ring of tubercles incomplete or lacking, ventrally unarmed. Tibia armed only with hairs. Tarsus armed with many hairs, mesoventral row of tubercles distinct. Penis 3.5 mm. long in northern specimens, 2.2 mm. long in southern specimens, alate part lacking but in the place where the alate part is normally

found the penis is so strongly compressed as to form a vertical bar, extending in a horizontal plane from the dorsal margin of this bar is a very thin plate. The lateral pockets thus formed enclose an opaque filmy substance. Tip of penis shaped as spear-head, lateral margins very heavily scleritized. Legs long and slender.

Dorsum golden-yellow, central marking obsolete. Eye tubercle light in front usually dark grey or black above. Palpus golden-yellow. Trochanters and bases of femora golden-yellow, legs dark brown or black distally. Tibia II sometimes with white band at apex as in *L. longipes*. F F FFF

Female. Average length, 6 mm. Average length of legs I, 39; II, 82; III, 39; IV, 51 mm. (Florida specimens); I, 22; II, 48; III, 22; IV, 39 mm. (specimens from Pennsylvania, New York, Michigan, etc.).

Abdomen rounded caudad. Femur of palpus extending above surface of carapace slightly less than one-half the height of the eye tubercle.

Central markings usually distinguishable, sometimes obsolete. Tibia II ringed with white or yellow at apex as in *L. longipes*.

This species is sometimes divided into two subspecies which Roewer (Weberknechte) separates in the following key:

Length of legs I, 25; II, 51; III, 26, IV, 26 mm.----------*L. p. politum*
Length of legs I, 40; II, 80; III, 40; IV, 58 mm.----------*L. p. magnum*

Types 3 ♂; type locality, Champaign County, Illinois.

Nova Scotia: Truro, July 18, 1913, 1 ♀. *Maine:* Orono, July, 1924, 20 specimens. *New Hampshire:* Meredith, Aug. 22, 1925, 1 ♂; Franconia Notch, Aug. 20, 1925, 2 imm. *Massachusetts:* Quincy, July, 1875, 1 ♂, 1 ♀; Middleton, Aug., 2 ♂ (J. H. C.); Wellfleet, Aug. 28, 1918, 2 ♂ (Banks). *Connecticut:* New Canaan, Sept. 15, 1905, 1 specimen (Britton). *Michigan:* Huron Co., July 21, 1931, 65 specimens (Hubbell). *Indiana:* Wyandotte, 2 ♂ (Banks). *Ohio:* Preble Co., Sept. 3, 1930, 2 ♂ (Hubbell); Cambridge, 1 ♂ (Banks); Hocking Co., Sept. 10, 1931, 1 ♂ (Hubbell). *New York:* Lowville, Aug. 8, 1 ♀; Fairhaven, July 31, 1932, 2 ♂, 6 ♀ (Hughes); Hillsdale, Sept. 2, 1925, 1 ♂; Forest Hills, Sept., 1914, 1 ♂ (Crosby); Mt. Whiteface, Aug. 21, 1916, 1 ♂; Rhinebeck, July 29, 1907, 3 ♂, 1 ♀; Riverhead, Sept. 10, 1922, 1 ♂; Etna, Nov., 1912, 4 ♂, 1 ♀; Pearl Point, July 29, 1920, 1 ♂; Hunter, Aug. 10, 1923, 2 ♂; Black Mountain, Aug. 1, 1920, 1 ♂; Sea Cliff, Sept. 6, 1925, 2 ♂, 1 ♀ (Wolf & Taub); number of specimens from Tompkins Co., 4 ♀ (Dietz). *Pennsylvania:* Hazleton, 1925, 5 ♂ (Dietz); Orangeville, Aug., 1932, 6 ♂, 3 ♀ (Hughes); Lehighton, 1 ♂. *New Jersey:* Atlantic Co., Aug. 6, 1931, 12 ♂, 8 ♀; Sept. 4, 1931, 27 specimens. *Virginia:* Bath Co., 3 ♀ (Shaler). *Missouri:* Creve Coeur Lake, Aug. 4, 1926, 4 ♀; Columbia, June, 1905, 1 imm. (Crosby). July, 1904, 1 ♂, 1 ♀. *Oklahoma:* Wichita National Forest, Sept. 10, 1930, 1 ♀ (Hubbell). *Arkansas:* West Helena, Aug. 13, 1929, 4 ♂, 2 ♀ (Hubbell). *Tennessee:* South Fulton, Aug. 10, 1929, 4 ♂, 12 ♀ (Hubbell). North Carolina: Raleigh, June, 1912, 1 imm. *South Carolina:* Greenwood, Oct. 5, 1930, 1 ♂ (Hubbell); Beaufort Co., Sept. 25, 1930, 1 ♂ (Hubbell); Berkeley Co., Sept. 25, 1930, 1 ♀ (Hubbell); Colleton Co., Oct. 3, 1930, 1 ♂ (Hubbell); Kershaw Co., Oct. 4, 1930, 1 ♂ (Hubbell); Florence Co., Oct. 3, 1930, 2 ♂ (Hubbell). *Texas:* San Tomas, Jan. 9, 1895, 1 ♂, 1 ♀ (Banks); *Louisiana:* Baton Rouge, Sept. 13, 1930, 1 ♂, 3 ♀ (Hubbell). *Mississippi:* Lucedale, Sept., 1931, 1 ♂, 1 ♀ (Dietrich). *Alabama:* Opeleka, Aug. 23, 1929, 1 ♀ (Hubbell); Auburn, July 20, 1924, 1 ♂, 1 ♀ (Good). *Georgia:* Bainbridge, July 14, 1909, 1 ♂ (Bradley); Athens, June 15, 1909, 1 ♂; Atlanta, July 10, 1910, 2 ♂ (Bradley); Okefinokee Swamp, June, 1912, 1 ♀ (Crosby). *Florida:* Santa Rosa Co., July 26, 1930, 7 ♂, 3 ♀; Arcadia, Oct. 18, 1930, 1 ♂; Liberty Co., July 19, 1930, 54 specimens; Chattahoochee, July 24, 1930, 11 specimens, June 11, 1930, 10 specimens

(Van Hyning); Pensacola, July 27, 1930, 1 ♀; Marianna, July 24, 1930, 3 ♂; Liberty Co., May 29, 1931, 15 ♂, 7 ♀, Aug. 1, 1925, 1 ♀.

Leiobunum relictum sp. nov.

Male. Average length 6 mm.; average length of legs I, 40; II, 78; III, 41; IV, 57 mm.

Dorsum rather coarsely granulated, anterior margin of carapace unarmed. Eye tubercle deeply canaliculate, a row of sturdy black-tipped tubercles over each carina. Abdomen truncate or subtruncate caudad. Venter: free sternites granular and with a few very minute tubercles. Genital operculum armed with minute rounded tubercles, marginal rows of denticles lacking. Coxae closely tuberculate, marginal rows of denticles distinct on anterior side of coxae I - IV, and on posterior side of coxa IV, indistinct and irregular on posterior side of coxae I - III.

Palpus: femur slender, nearly straight, extending above surface of carapace a distance very slightly greater than the height of eye tubercle; armed distolaterally with an area of black-tipped tubercles, this area tapering proximally until it becomes only a narrow ventrolateral border; dorsal surface with a very few such tubercles on distal portion; armed mesally with a short row of light brown tubercles on proximal part and a few scattered tubercles on distal part; unarmed ventrally and ventromesally. Patella armed laterally with a number of sturdy black-tipped tubercles, these tubercles less numerous dorsally and mesally, lacking ventrally. Tibia armed with a ventrolateral area of sturdy black-tipped tubercles, otherwise covered with numerous brown hairs. Tarsus thickly covered with brown hairs, mesoventral row of tubercles well developed. Penis 3.9 mm. long, alate part lacking, shaft of penis broad proximally tapering into a narrow dorsoventrally flattened rod with a long upturned tip. Legs of moderate length and diameter.

Dorsum with a very distinct dark brown central marking. Lateral margins of dorsal scutum edged with brown. Between central marking and lateral edgings are two lateral longitudinal yellow areas which are usually more or less mottled with brown. Tergites caudad of eye tubercle with irregular transverse rows of yellow spots. Eye tubercle black above, usually lighter below and in front. Venter a uniform light yellow. Palpus light yellow except patella and distal end of femur which are slightly darker. Legs: trochanters brown on cephalic and caudal surfaces, mesal surfaces lighter, lateral surfaces very nearly concolorous with coxae. Femora with brown bases and white apices, otherwise yellow. Patella brown. Tibiae yellow with white apices which are preceded by a brown band. Articulations of tarsi and false articulations of metatarsus not ringed with white as in *L. bicolor*.

Female. Average length, 8 mm. Average length of legs I, 38; II, 72; III, 38; IV, 56 mm.

A few small tubercles on anterior margin of carapace in median line. Abdomen rounded caudad. Femur of palpus extending above surface of carapace only about one-fourth the height of the eye tubercle. Armature of palpus similar to that of male.

Holotype ♂. Allotype ♀, Cache Creek Canyon, Wichita Mts., Oklahoma. Cornell collection.

Oklahoma: Comanche Co., 3 ♂, 3 ♀; Wichita National Forest, Sept. 10, 1930, 20 ♂ (Hubbell); Wichita Mts., Sept. 10, 1930, 30 ♂, 22 ♀ (Hubbell); Elk Mountain, July 1, 1 ♂, 1 ♀ (Bird).

Leiobunum serratipalpe Roewer

Leiobunum serratipalpe Roewer, Naturw. Ver. Hamburg Abh. 19(4):222, 1910.
Leiobunum serratipalpe Roewer, Weberknechte, p. 901, f. 1055. 1923.
Leiobunum serratipalpe Crosby and Bishop, Elisha Mitchell Sci. Soc. Jour. 40:13. 1924

Male. Length 6 mm. Length of legs, I, 35; II, 65; III, 36; IV, 54 mm. (specimens from Connecticut). Length 7.5 mm. Length of legs I, 31; II, 62; III, 34; IV, 46 mm. (specimen from Kentucky). Length 7 mm. Length of legs I, ?; II, 77; III, 36; IV, 53 mm. (specimens from Ohio).

Dorsum finely granulated; anterior margin of carapace armed with a patch of tubercles in the median line and a patch on either side just caudad of the first coxae. Eye tubercle very shallowly canaliculate, armed with well developed rows of tubercles over each carina. Abdomen pointed caudad. Venter: free sternites finely granulated. Genital operculum of specimens from Connecticut with only a few small tubercles in center, specimens from Kentucky and Ohio with numerous tubercles over entire surface; marginal rows of denticles distinct on all specimens. Coxae with a number of small tubercles, marginal rows of denticles poorly developed on the posterior side of coxae I and II, lacking on coxa III, and well developed on coxa IV; anterior rows of denticles well developed on coxae I - III and poorly developed on coxa IV.

Palpus: femur proximally slender, distally much thickened and curved approximately 45 degrees, extending above surface of carapace a distance equal to 1.5 times the height of the eye tubercle; armed distodorsally with small tubercles, distolaterally a slight swelling on which are a number of sturdy black tubercles. Patella short, thickened, armed with scattered small tubercles and a short transverse row of large tubercles on the distodorsal margin. Tibia curved dorsally and strongly thickened proximally, armed ventrally with a number of tubercles on the proximal portion at least and a row of tubercles ventromesally on the distal part. Tarsus slender, armed with a ventromesal row of close-set tubercles. Penis 4.6 mm. long, alate part lacking. Shaft of penis straight, roughly cylindrical except at distal end which is slightly flattened and bent dorsally. One specimen taken with penis like that of *calcar*. Legs of moderate length and diameter.

Dorsum golden-yellow. Central marking subobsolete. (Roewer described itas velvet brown.). Eye tubercle brown above, lighter below in front. Venter very nearly concolorous with dorsum. Palpus uniformly yellow (Connecticut specimen), or with distal part of femur, patella and tibia brown (Kentucky specimen). Legs golden-yellow, (Connecticut specimen) or dark brown except trochanters and bases of femora which are golden brown (Kentucky specimen).

Female of this species is not known but is likely to be quite similar to that of *L. calcar*.

The similarity of this species to *L. calcar* has led some to believe that this species is a synonym. The variation in the shape of the penis adds weight

to this opinion. However, an examination of the scanty material at hand seems to indicate that this species should be retained for the present at least.

Types 2 ♂. Type locality, Long Lake, New York, Cold River, North America. Collection Museum of Budapest.

Connecticut: Storrs, July 28, 1923, 1 ♂. *Ohio:* Hocking Co., Sept. 10, 1931, 2 ♂ (Hubbell). *Kentucky:* Bell Co., Aug. 12, 1919, 1 ♂ (Funkhauser). *North Carolina:* Roan Mountain 2 ♂, 1 ♀ (Banks). *Alabama:* Talladega Co., June 25, 1914, 1 ♂.

Leiobunum speciosum Banks

Leiobunum speciosum Banks, Acad. Nat. Sci. Phila. Proc. 52:541. 1900.
Leiobunum speciosum Banks, Am. Nat. 35:676. 1901.
Leiobunum speciosum Roewer, Naturw. Ver. Hamburg Abh. 19(4): 228, pl. 6, f. 15. 1910.
Leiobunum speciosum Comstock, Spider Book, p. 73. 1912.
Leiobunum speciosum Roewer, Weberknechte, p. 904, f. 1075, 1923.
Leiobunum speciosum Crosby and Bishop, Elish Mitchell Sci. Soc. Jour. 40:13, 15. 1924.
Leiobunum speciosum Walker, Ohio Biol. Surv. Bul. 19:166, pl. 2, f. 17. 1928.

Male. Average length 5.5 mm.; average length of legs I, 48; II, 98; III, 49; IV, 67 mm.

Dorsum finely granulated, anterior margin of carapace with a very few small tubercles in median line. Eye tubercle shallowly canaliculate, armed with a row of small black tubercles over each carina. Abdomen usually bluntly rounded behind, less often long and pointed as in *L. vittatum*. Venter: free sternites granulated but not tuberculate. Genital operculum armed with a number of orange-yellow tubercles but lacking marginal rows of denticles. Coxae thickly set with these tubercles and with marginal rows of denticles present on both anterior and posterior side.

Palpus: femur slender, curved approximately fortyfive degrees, extending above surface a distance equal to three times the height of the eye tubercle; armed distodorsally with a short medial row of small black-tipped, forward-pointing tubercles, laterally with a row of fairly large black-tipped tubercles which is often supplemented on distal end by additional tubercles or rows of tubercles, ventrally unarmed. Patella long, nearly straight, armed laterally with a single row of long black-tipped tubercles, sometimes a medial dorsal row of smaller tubercles or traces of such a row. Tibia armed ventrolaterally with one row of black-tipped tubercles extending the full length of the segment and a second row parallel to and just ventrad of the first row extending along the proximal third, armed distomesally with a short row of these tubercles. Tarsus with yellow hairs, mesoventral row of tubercles very large and prominent. Penis 4 mm. long, alate part lacking. Proximal third of penis a broad, ovoid shaft which tapers into a thin cylindrical rod that forms the distal half. Legs of moderate length and diameter.

Dorsum golden-yellow, central marking usually obsolete, less often subobsolete or distinct. Eye tubercle black above, brown below in front. Venter very slightly lighter than dorsum. Palpus orange-yellow with transverse bars of lighter color of dorsal surface of femur and tibia. Legs: trochanters and bases of femora black, contrasting strongly with coxae, remainder of femora and other segments dark brown.

Female. Length, 7 mm. Length of legs I, 42; II, 86; III, 42; IV. 59 mm. Abdomen somewhat pointed caudad. Femur of palpus extending above surface of carapace about twice the height of the eye tubercle not as strongly curved as in male. Coloration same as in male.

Three males of this species from Quicksand, Kentucky have their legs banded with black like *L. formosum*.

Type, ♀, no data, collection Harvard Museum Comparative Zoology.

Kentucky: Quicksand, August 1925, 4 ♂ (Funkhtouser). *South Carolina:* Greenwood, Oct. 5, 1930, 2 ♂ (Hubbell). *Georgia:* Decatur Co., July 1912, 1 ♂, 1 ♀, June 7, 1911, 1 ♂ (Bradley); Tallulah Falls, July 27, 1909, 1 ♂ (Bradley). *Florida:* Liberty Co., July 19, 1930, 3 ♂, Nov. 15, 1931, 7 ♂, 1 ♀ (Hubbell). *Alabama:* Walker Co., Oct. 15, 1912, 1 ♀, Oct. 20, 1912, 1 female (H. H. Smith); Lauderdale Co., Oct. 1909, 1 ♂, 2 ♀ (H. H. Smith).

Leiobunum townsendi Weed

Leiobunum townsendi Weed, Am. Nat. 27:298. 1893.
Leiobunum townsendi Banks, N. Y. Ent. Soc. Jour. 2:145. 1894.
Leiobunum townsendi Banks, Am. Nat. 35:676. 1901.
Leiobunum townsendi Banks, U. S. Nat. Mus. Proc. 23:588. 1901.
Leiobunum townsendi Banks, Acad. Nat. Sci. Phila. 53:593. 1901.
Leiobunum townsendi Roewer, Naturw. Ver. Hambur Abh. 19(4):231. 1910.
Leiobunum townsendi Comstock, Spider Book, p. 73. 1912.
Leiobunum townsendi Roewer, Weberknechte, p. 906. 1923.
Leiobunum townsendi Crosby and Bishop, Elisha Mitchell Sci. Soc. Jour. 40:13. 1924.
Leiobunum townsendi Crosby, Ent. Soc. Washington Proc. 28(1):1. 1926.

Male. Average length 5 mm.; average length of legs I, 47; II, 83; III, 48; IV, 62 mm.

Dorsum caudad of eye tubercle coarsely granulated, anterior margin of carapace unarmed. Eye tubercle deeply canaliculate, rows of tubercles over carinae lacking. Abdomen truncate caudad. Venter: free sternites smooth. Genital operculum armed only with marginal rows of denticles. Coxae each with anterior and posterior rows of denticles, otherwise unarmed.

Palpus: femur slender, nearly straight, extending above surface of carapace only as high as the base of eye tubercle; armed ventrally with a number of sturdy black-tipped tubercles, dorsal, lateral and mesal surfaces armed only with a few tubercles on distal end. Patella armed dorsally, laterally and mesally with numerous black-tipped tubercles. Tibia armed dorsally, laterally and mesally with hairs only; ventrally with a number of tubercles, particularly on proximal half. Tarsus covered with light brown hairs, mesoventral row of tubercles present. Penis 3.3 mm. long, alate part .7 mm. long and extending to a point .4 mm. from the distal end. Shaft of penis not at all flattened dorsoventrally but is roughtly circular in cross-section, a slight keel present on dorsal surface. Shaft large proximally constricted about midway and expanded again distally. Alate part much wider than shaft which is compressed to form tip not abruptly as *nigripes* but gradually. Horizontal portion of tip much broader ventrally than dorsally, upturned part of tip proximally broader than dorsal surface of horizontal part. Legs of moderate length and diameter.

Anterior part of carapace golden-yellow with brown markings in median line and on lateral margins. Eye tubercle pale ventrally, as seen from above

dark medially with a light line above each eye. The two transverse ridges behind eye tubercle brown with light spots. Remainder of dorsum light brown with numerous minute and often indistinct light spots. Central marking subobsolete. Venter yellow: coxae often with a slight reddish cast. Palpus yellow, distal end of femur, patella tibia and extreme proximal end of tarsus mottled with brown dorsally. Chelicera with first and second segment often marked with white dorsally. Legs: trochanters dark on cephalic and caudal surfaces, mesal and lateral surfaces light, the outer being very nearly concolorous with the coxae. Femora light brown with white bands at apices; these bands accentuated by being preceded by a slightly darkened portion. Patellas dark brown. Tibiae dark brown, apices dark brown preceded by white bands. Metatarsi and tarsi light brown.

Female. Length, 7 mm. Length of legs I, 35; II, 65; III, 35; IV, 45 mm.

Abdomen rounded caudad. Femur of palpus extending but slightly above the surface of carapace, unarmed or with a few scattered tubercles ventrally. Patella and tibia armed only with hairs. General coloration of dorsum darker than in male. Central marking faint.

Types, one ♂, two ♀. Las Cruces, New Mexico.

Utah: Fillmore Canyon, Sept. 17, 15 specimens (Chamberlin). *Colorado:* Manitou, August 26, 1924, 4 ♀. *Arizona:* Fort Grant, July 15, 1917, 8 ♂. *New Mexico:* Carlsbad Cave, April 13, 1935, 1 imm. (Babcock), 1 imm. (Babcock); Las Cruces, 1 ♀ (Banks); White Mountains, 2 ♂, 2 ♀ (Banks); Beulah, 1 ♂ (Banks); Pecos, July 1903 (Cockerell). *Texas:* Anhalt, June 28, 10 ♂, 3 ♀; Helotes, March 20, 1925, 1 imm. (Wright); Belfrage. *Mexico:* 6 imm. (Weld).

Leiobunum uxorium Crosby and Bishop

Leiobunum uxorium Crosby and Bishop, Elisha Mitchell Sci. Soc. Jour. 40:13, 18 pl. 2 f. 13, 14. 1924.

Male. Average length 4 mm.; average length of legs I, 49; II, 90; III, 49; IV, 68 mm.

Dorsum finely granulated, anterior margin of carapace usually with a few small tubercles in the median line. Eye tubercle deeply canaliculate, armed with a few small tubercles over each carina. Abdomen truncate or subtruncate caudad. Venter: free sternites granulated but not tuberculate. Coxae thickly set with small tubercles, anterior marginal rows of denticles usually present on coxae I - IV; posterior rows lacking on coxae I - III, present on coxa IV. Genital operculum more roughly granulated than free sternites but not ordinarily tuberculate, marginal rows of denticles lacking.

Palpus: femur slender, curved distally, extending above surface of carapace a distance equal to one and one-half times the height of the eye tubercle; armed ventrolaterally with an irregular row of stumpy concolorous tubercles, distodorsally with a few scattered tubercles, unarmed ventrally. Patella often armed with three irregular longitudinal rows of tubercles, one laterad, one dorsolaterad, and one dorsomesad. Tibia armed with yellow hairs and a row of tubercles proximolaterally, sometimes a ventrolateral row is present extending the length of the segment, sometimes a short ventromsal row present on distal part. Tarsus with yellow hairs, mesoventral row of large tubercles present. Penis 2.5 mm. long, alate part lacking. Shaft of penis a broad

ovoid shaft which tapers quickly into a narrow rod which is slightly flattened dorsoventrally except the extreme distal part including the upturned tip. Legs very long and slender.

Dorsum golden-yellow, central marking obsolete or subobsolete. Eye tubercle dark above slightly lighter in front. Venter slightly lighter than dorsum. Palpus yllow, dorsal surface of tibia and femur with light transverse bars. Trochanters very dark brown or black, contrasting strongly with coxae and dorsum. Legs a uniform dark brown or black.

Female. Length, 6.5 mm. Length of legs I, 41; II, 82; III, 41; IV, 60 mm.

Abdomen rounded caudad. Femur of palpus extending above surface of carapace a distance equal to height of eye tubercle, armed with a ventrolateral row of tubercles a few scattered tubercles distolaterally. Tibia with a mesal and a lateral row of tubercles.

Dorsum light brown, central marking distinct or faint. Venter noticeably lighter than dorsum. Legs usually a little lighter than those of male.

Holotype ♂, allotype ♀, collected in coitu, Oteen, North Carolina. Oct. 20, 1923. Cornell collection.

Ohio: Hocking Co., Sept. 10, 1931, 2 ♂, 2 ♀ (Hubbell); 2 ♂ (Walker). *New York:* Kershoner, Sept. 1903, 2 ♂, 1 ♀. *Pennsylvania:* Gettysburg, Oct. 3, 1923, 1 ♂ (Crosby and Bishop); Bedford, July 7, 2 ♂, 1 ♀ (Shaler). *Virginia:* Strassburg, Oct. 4, 1923, 1 ♀ (Crosby and Bishop); Buchanan, Oct. 6, 1923, 1 ♂ (Crosby and Bishop); Pennington Gap, 4 ♂ male; Falls Church, 5 ♂, (Banks). *North Carolina:* Madison, Oct. 8, 1923, 1 ♂ (Crosby and Bishop); Oteen, Oct. 20, 1923, 20 specimens (Crosby and Bishop); Lake Waccaman, Oct. 21, 1926, 20 ♂, 10 ♀; Macon Co., Oct. 16, 1926, 1 ♂. *Tennessee:* Gatlinburg, Oct. 7, 1926, 3 ♂, 1 ♀. *South Carolina:* Beaufort Co., Oct. 3, 1930, 4 ♂, 1 ♀ (Hubbell); Berkely Co., Oct. 3, 1930, 4 ♂, 1 ♀ (Hubbell); Berkely Co., Oct. 3, 1930, 4 ♂, 1 ♀ (Hubbell). *Alabama:* Auburn, 1 ♂, 1 ♀ (Banks).

Leiobunum ventricosum (Wood)

**Phalangium ventricosum* Wood, Essex Inst. 6:32, 33, 39, f. 7, 1870.
Phalangium ventricosum Packard, Guide to Study of Insects p. 657, f. 633. 1869.
Phalangium ventricosum Underwood, Can. Ent. 17:169. 1885.
Leiobunum ventricosum Weed, Am. Nat. 21:935. 1887.
Leiobunum ventricosum Weed, Ill. State Lab. Nat. Hist. Bul. 3:104. 1889.
Leiobunum ventricosum Weed, Am. Nat. 24: 918. 1890.
Leiobunum ventricosum Weed, Am. Ent. Soc. Trans. 19:188, 264, pl. 5. 1892.
Leiobunum ventricosum Weed, Am. Nat. 27:294, 534, pl. 14, f. 1. 1893.
Leiobunum ventricosum hyemale Weed, Psyche 6:427, pl. 13, 14. 1893.
Leiobunum ventricosum Banks, N. Y. Ent. Soc. Jour. 2:146. 1894.
Leiobunum ventricosum Weed, Life Hist. Am. Insects, p. 262, 268, pl. 21. 1897.
Leiobunum ventricosum Banks, Am. Nat. 35: 677. 1901.
Leiobunum ventricosum Banks, N. Y. Ent. Soc. Jour. 12:256. 1904.
Leiobunum ventricosum Banks, Boston Soc. Nat. Hist. Occasional Papers, 7(10):2. 1908.
Leiobunum ventricosum Roewer, Naturw. Ver. Hamburg Abh. 19(4):225, pl. 3, f. 23, 24, 1910.
Leiobunum ventricosum Comstock, Spider Book, p. 73. 1912.
Leiobunum ventricosum Crosby and Bishop, Elisha Mitchell Sci. Soc. Jour. 40:13. 1924.

*Author's copy issued August 1886.

Leiobunum ventricosum Crosby and Bishop, Cornell Univ. Agr. Exp. Sta. Mem. 101:1076. 1928.
Leiobunum ventricosum Walker, Ohio Biol. Surv. Bul. 19:165, pl. 2, f. 21. 1928.

Male. Average length 8 mm.; average length of legs I, 56; II, 109; III, 56; IV, 80 mm. (Florida specimens). Average length 6 mm.; average length of legs I. 34; II, 65; III, 34; IV, 53 mm. (specimens from northeastern United States.).

Dorsum finely granulated, a few golden tubercles present on the anterior margin of carapace in median line. Eye tubercle very shallowly or not at all canaliculate, rows of tubercles over carinae poorly developed or lacking. Abdomen extremely long and pointed caudad. Venter: free sternites granulated, sometimes with a very few tiny golden tubercles. Genital operculum with a number of golden tubercles, marginal rows of denticles distinct. Coxae thickly set with tubercles, marginal rows of denticles usually present on both anterior and posterior sides.

Palpus: femur moderately robust, curved distally, extending above the surface of carapace a distance approximately equal to the height of the eye tubercle; armed distodorsally with a few small tubercles, distolaterally with a number of tubercles, ventrolaterally with a well developed row of tubercles, distomesally with a few tubercles, sometimes a ventromesal row of tubercles present. Patella armed dorsally and on sides with a few small tubercles. Tibia with only hairs or with a few tubercles ventrally. Tarsus covered with dark hairs, mesoventral row of tubercles distinct. Penis 5 - 7.5 mm. long (southern specimens having the longer penis), alate part 1 - 1.5 mm. long and extending to a point .5 - .6 mm. from the distal end. Shaft of penis a broad flat blade with heavily scleritized lateral margins; this blade contracted slightly proximally broadened towards the middle and tapered to a narrow upturned tip distally. Alate part is tapered distally in Florida specimens, all other specimens seen have an alate part which is truncated distally. Legs very long and moderately robust.

Dorsum golden to golden brown, central marking present and of slightly darker shade, a number of golden flacks often present. Eye tubercle dark brown or black, lighter along median line. Venter concolorous with or a little lighter than dorsum. Palpus and legs (excepting coxae) concolorous with dorsum.

Female. Average length of body 11 mm. Average length of legs I, 50; II, 100; III, 51; IV, 68 mm. (Florida specimens). Average length of body 9.5 mm. Average length of legs I, 32; II, 60; III, 32; V, 45 mm.

Femur of palpus slightly shorter than that of male, extending above carapace approximately one-half the height of eye tubercle, straight, armed similarly to that of male.

Dorsum golden to golden brown often darker than that of male. Central marking usually more distinct than in male. Venter a little lighter than dorsum.

Weed described a southern form of this species as *L. v. hyemale*. Because of the distinctly different penis the form found in Florida might also be considered a subspecies. The following key would then separate the three forms.

1. Length of second leg less than 80 mm._____*L. v. ventricosum* (Wood) Weed
   Length of second leg 90-120 mm. _____2
2. Alate part of penis truncate distally_____*L. v. hyemale* Weed
   Alate part of penis tapered distally _____**L. v. floridanum** subsp. nov.

Holotype ♀. Philadelphia, Penn.

Ontario: Sanford, June 3 ♂, 1 ♀. *Maine:* Warwick, 3 ♂ (Edwards). *New Hampshire:* Franconia, 2 ♂, 2 ♀ (Banks); Pike, July 1, 1908, 1 ♀. *Massachusetts:* Feltonville, 1 ♀ (Gilson); Shanon, 1920, 1 ♀ (Cushing); Holliston, 1 ♂; Nantucket, June, 2 ♂, 1 ♀ (Johnson). *Connecticut:* Salisburg, June 29, 1930, 1 ♀. *Wisconsin:* St. Croix Falls, 4 ♂, 5 ♀ (Banks). *Michigan:* Huron Co., July 22, 1931, 2 ♂ (Hubbell). *Ohio:* Hocking Co., May 30, 1932, 1 ♂ Crosby); Cambridge, 1 ♂ (Banks); Columbus, 5 ♂, 4 ♀ (Walker). *New York:* Washington Co., July 29, 1920, 1 ♀; River Head, Sept. 10, 1922, 1 ♀; Adirondack Lodge, July, 1929, 2 ♂; Otto, Jan. 20, 1903, 1 imm. (Comstock): Long Lake, August 9, 1931, 1 ♂ (Crosby); Fairhaven, July 31, 1932, 1 ♂ (Hughes); Cinnamon Lake, June 5, 1925, 1 ♀; Portage, June 13, 1915, 1 ♂ (Crosby); Chautauqua Co., June 19, 1922, 1 ♀; Rock City, June 1915, 1 ♀; Lake Keuka, June 24, 1907, 1 ♂; Schodack Landing, June 10, 1919, 1 ♀; Indian Lake, June 17, 1925, 1 ♂; Orleans Co., June 11, 1922, 1 ♀; Potter Swamp, July 16, 1926, 1 ♀; Letchworth Park, July 9, 1922, 1 ♀; Franklin Co., July 19, 1931, 2 ♂ (Crosby and Hammer); Durlandville, 1930, 1 ♂ (Maughn); Montauk, June 25, 1927, 1 ♂; Oswegatchie, June 15, 1930, 1 ♀ (Redman); Green Port, June 25, 1920, 2 ♂, 1 female; Montauk, June 20, 1927, 1 ♂, 1 ♀, (Lathan). *Pennsylvania:* Hazelton, Nov. 19, 1925, 2 ♀ (Dietz); McVrytown, July, 1 ♀; Sullivan Co., July 12, 2 ♀; Cumberland Valley, August 7, 1 ♂; Centre Co., July 25, 1 ♂; Philadelphia, 2 ♂ (Banks), *Kentucky:* Bee Spring, 1 ♀ (Sanborn), June 8, 2 ♂, 3 ♀ (Sanborn). *Tennessee:* Lookout Mountain, 1 ♂ (Banks); Pattonville, 4 ♂, 5 ♀ (Banks); Obion, Aug. 11, 1929, 2 ♂ (Hubbell); Fulton, August 10, 1929, 2 ♀ (Hubbell); Silers Bald, July 1, 1928, 3 ♂ (Stanley). *Virginia:* Pennington Gap, 1 ♂, 1 ♀; Falls Church, 1 ♂, 3 ♀ (Banks); Great Falls, 1 ♂, 3 ♀ (Banks); Chain Bridge, 1 ♂ (Banks); Onley, June 14, 1920, 1♀. *Mississippi:* Pontatoc, Aug. 15, 1929, 1 ♂ (Hubbell). *Georgia:* Tallulah, Aug. 1887, 3 ♂; Arnuche, Aug. 26, 1929, 1 ♀ (Hubbell); Tallulah Falls, 1 ♂; Clayton, May 1911, 2 ♂, 1 ♀. *Florida:* Chattahoochee, July 24, 1930, 1 ♂; Liberty Co., July 29, 1931, 6 ♂, 1 ♀, May 27, 1931, 1 ♂, July 19, 1930, 1 ♂, 1 ♀; Marianna, July 25, 1930, 1 ♂, 1 ♀.

Leiobunum verrucosum (Wood)

Phalangium verrucosum Wood, Essex Inst. Commun. 6:29, 40, f. 1870.
Phalangium verrucosum Underwood, Can. Ent. 17:169. 1885.
Leiobunum verrucosum Weed, Am. Ent. Soc. Trans. 19:189, pl. 6. 1892.
Leiobunum verrucosum Banks, Am. Nat. 35:676. 1901.
Leiobunum verrucosum Banks, Boston Soc. Nat. Hist. Occasional Paper 7(10):2. 1908.
Leiobunum verrucosum Roewer, Naturw. Ver. Hamburg Abh. 19(4):217, pl. 3, f. 22. 1910.
Leiobunum verrucosum Comstock, Spider Book, p. 73. 1912.
Leiobunum verrucosum Roewer, Weberknechte, p. 898. 1923.
Leiobunum verrucosum Crosby and Bishop, Elisha Mitchell Sci. Soc. Jour. 40:13. 1924.
Leiobunum verrucosum Crosby and Bishop, Cornell Univ. Agr. Exp. Sta. Mem. 101:1076. 1928.
Leiobunum verrucosum Walker, Ohio Biol. Surv. Bul. 19:166, pl. 2, f. 19. 1928.

Male. Average length, 5 mm.; average length of legs I, 46; II, 86; III, 47; IV, 58 mm.

Dorsum uniformly granulated; anterior margin of carapace armed with a few small tubercles in median line. Eye tubercle high, constricted basally, canaliculate, well armed over each carina with a row of sturdy tubercles. A group of a few small tubercles on the caudolateral corners of the fused abdominal scutum. A few tubercles present on last free tergite and anal operculum, sometimes also on other free tergites. Abdomen usually subtruncate caudad, sometimes pointed. Venter: free sternites armed with numerous small white tubercles. Genital operculum armed with many small tubercles, marginal rows of denticles lacking. Coxae thickly set with tubercles, marginal rows of denticles absent on posterior side of coxae I - III, present and well developed on anterior side of coxae I - III and on both sides of coxae IV.

Palpus: femur slender nearly straight, extending above surface of carapace a distance equal to one-half the height of eye tubercle, armed on distal end with a few tubercles on mesal, dorsal and lateral surfaces, ventral surface of femur with many white tubercles. Patella armed dorsally and laterally with many small tubercles. Tibia armed with many small tubercles on dorsal and lateral surfaces. Tarsus with ventromesal row of tubercles very poorly developed. Penis 2.9 mm. long, alate part .7 mm. long and extends to a point .5 mm. from tip. Proximal part of penis a broad flat blade with heavily scleritized lateral margins, strongly compressed and bent dorsally at distal end. Legs long and of moderate diameter.

Dorsum a nearly uniform brown. Eye tubercle very dark brown or black above, lighter below in front. Central markings indistinct or subobsolete. Venter silver-white, coxae included. Palpi yellow. Trochanters and bases of femora black, contrasting with coxae, remainder of legs golden-brown.

Female. Average length 8 mm. Average length of legs I, 42; II, 83; III, 42; IV, 59 mm. (specimens from South Carolina). Length 8 mm. Length of legs I, 33; II, 62; III, 33; IV, 45 mm. (specimens from New York.).

Abdomen rounded or slightly pointed caudad. Central marking present but usually faint.

Types ♂.

Massachusetts: Wellfleet, August 28, 1918, 1 ♂ (Banks); Nantucket Sept. 13, 1892, 3 ♀ (Henshaw). *New York:* New York City, August 20, 1926, 1 ♀ (Lathan); Staten(Lathan); Staten Island, July 1919; 2 ♂ (Burns); Ronkonkoma, Sept. 9, 1922, 2 ♀; Orient, Aug. 1, 1925, 1 ♂ (Lathan); Sept. 13, 1925, 2 ♀ (Lathan). *New Jersey:* Great Notch, 1 ♂ (A.M.N.H.). *North Carolina:* Fort Fisher, Oct. 22, 1926, 1 ♂. *South Carolina:* Berkley Co., Sept. 25, 1930, 9 ♂, 9 ♀ (Hubbell); Darlington Co., Oct. 3, 1930, 2 ♂ (Hubbell).

Leiobunum vittatum (Say)

Phalangium vittatum Say, Phila. Acad. Nat. Sci. Jour. 2:65. 1821.
Phalangium dorsatum Say, Phila. Acad. Nat. Sci. Jour. 2:66. 1821.
**Phalangium vittatum* Wood, Essex Inst. Commun. 6:20, 39, f. 2. 1870.
**Phalangium dorsatum* Wood, Essex Inst. Commun. 6:20, 39, f. 1. 1870.
Phalangium dorsatum Packard, Guide to Study of Insects, p. 656, f. 632. 1869.
Phalangium vittatum Underwood, Can. Ent. 17:169. 1885.
Phalangium dorsatum Underwood, Can. Ent. 17:168. 1885.

*Author's copy issued August 1868.

Leiobunum vittatum Weed, Am. Nat. 21:935. 1887.
Leiobunum dorsatum Weed, Am. Nat. 21:935. 1887.
Leiobunum vittatum Weed, Ill. State Lab. Nat. Hist. Bul. 3:82, 85, 101. 1889.
Leiobunum dorsatum Weed, Ill. State Lab. Nat. Hist. Bul. 3:82, 83, 100. 1889.
Leiobunum vittatum Weed, Am. Ent. Soc. Trans. 19:263, pl. 12, 13, 14, f. 2. 1892.
Leiobunum vittatum Weed, Am. Nat. 26:786, 999. 1892.
Leiobunum vittatum Weed, Psyche 6:426, pl. 11, 12. 1893.
Leiobunum vittatum Weed, U. S. Nat. Mus. Proc. 16:545. 546, pl. 58, pl. 57, f. 3. 1893.
Leiobunum vittatum Weed, Life Hist. Am. Insects, p. 260, 264, pl. 19, f. 92, pl. 20, 1897.
Leiobunum vittatum Banks, Acad. Nat. Sci. Phila. Proc. 52:541. 1900.
Leiobunum vittatum Banks, Am. Nat. 35:675. 1901.
Leiobunum vittatum Banks, N. Y. Ent. Soc. Jour. 12:256. 1904.
Leiobunum vittatum Banks, Boston Soc. Nat. Hist. Occasional Papers 7(10):2. 1908.
Leiobunum vittatum Roewer, Naturw. Ver Hamburg Abh. 19(4):211, 212, pl. 5, f. 29, 30, pl. 6, f. 12, 1910.
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Male. Length of body 5 - 7 mm. Legs extremely variable in length the second leg varying from 50 to 88 mm.

Dorsum finely granulated, anterior margin of carapace sometimes with a few very small tubercles in median line. Eye tubercle usually shallowly canaliculate, sometimes rounded; rows of tubercles over each carina usually poorly developed. Abdomen pointed caudad. Venter: free sternites finely granulated, not at all tuberculate. Genital operculum armed only with a few small tubercles, marginal rows of denticles lacking. Coxae thickly set with tubercles, marginal rows of denticles present on both anterior and posterior sides.

Palpus: femur slender, curved approximately forty-five degrees, extending above surface of carapace a distance equal to three times the height of the eye tubercle; armed distodorsally with a short medial row of black-tipped forward-pointing tubercles, laterally with a row of fairly large black-tipped tubercles which is often supplemented on distal end by additional tubercles or rows of tubercles, mesally with only a short proximomesal row of tubercles, ventrally unarmed. Patella long, nearly straight, armed laterally with a single row of long, black-tipped tubercles. Tibia armed ventrolaterally with one row of black-tipped tubercles extending the full length of the segment and a second row parallel to and just ventrad of the first row extending along the proximal third, armed distomesally with a short row of these tubercles. Tarsus with yellow hairs, mesoventral row of tubercles very large and prominent. Penis 4 mm. long, alate part lacking. Proximal third of penis a broad, ovoid shaft, which tapers into a thin cylindrical rod that forms the distal half. Legs of moderate diameter, variable in length.

Dorsum golden-yellow to dark red-brown, central marking distinct, ex-

tending from eye tubercle to penultimate segment of abdomen. Often with numerous irregular light yellow and black markings laterad. Eye tubercle dark above, nearly concolorous with dorsum below. Venter sometimes slightly, often very much lighter than dorsum. Palpus light yellow to red-brown, usually with transverse bars of lighter color on dorsal surface of femur and irregular spots of similar color on patella and tibia. Legs: trochanters and bases of femora dark brown to black contrasting strongly with coxae, remainder of legs either light brown with darker annulations or nearly uniform dark brown or black.

Female. Length 7 - 8.5 mm. Legs variable in length.

Abdomen rounded caudad. Femur of palpus straight, extending above carapace a distance equal to the height of the eye tubercle; armed ventrolaterally with numerous tubercles and a few ventromesally. Patella with a lateral or with a mesal, dorsal and lateral row of small tubercles. Tibia of palpus with a group of tubercles proximally on the ventrolateral surface, sometimes also with a mesal row of tubercles.

Venter usually very much lighter than dorsum. Legs usually lighter and more often annulated than in male.

Roewer (Weberknechte) separates this species into three subspecies using the following key:

1. Legs relatively short; tarsus of palpus blackish ---------- *L. v. minor*
   Legs longer; tarsus of palpus light yellow ---------- 2
2. Leg II longer than 70-75 mm; leg IV about 64 mm. ---------- *L. v. vittatum*
   Leg II less than 70-75 mm.; leg IV about 36-44 mm. ---------- *L. v. dorsatum*

Described from males and females, "United States."

Manitoba: Ninette, 1 ♂, 1 ♀. *Ontario:* Unionville, Sept. 8, 1923, 1 ♀. *Maine:* Orno, July 1924, 2 imm.; Falmouth, Aug. 30, 1925, 4 ♀; Winterport, Aug. 29, 1925, 1 ♂. *Vermont:* Rutland, Aug. 17, 1925, 3 ♂, 1 ♀. *Connecticut:* New Canaan, Sept. 15, 1905, 2 ♂, 1 ♀ (Britton); New Haven, 1905, 1 ♂, 1 ♀ (Britton); Stoors, July 28, 1925, 1 ♂, 1 ♀. *Wisconsin:* Kelbourn, Sept. 20, 1908, 2 ♂, 2 ♀. *Iowa:* Sept. 1903, 1 ♂ (Bean); Ames, Oct. 2, 1924, 2 ♂, 2 ♀ (Drake). *Michigan:* Huron Co., July 1931, 4 ♂, 5 ♀, July 21, 1931, 1 ♂, 1 ♀, July 23, 1931, 1 ♂, 4 ♀, July 22, 1931, 32 specimens, July 20, 1931, 2 ♂, 2 ♀ (Hubbell); Livingston Co., July 28, 1932, 2 ♂, 1 ♀ (Hubbell); Ann Arbor, Aug. 2, 1931, 2 ♂, 1 ♀ (Hubbell); Washtenew Co., Sept. 20, 1930, 3 ♂, 5 ♀ (Rogers); Milford, Aug. 28, 1930, 1 ♂, 2 ♀ (Hubbell). *Illinois:* Urbana, Aug. 2, 1926, 1 ♂ (Shackleford). July 10, 1908, 6 imm. (Ewing). *Indiana:* Hanover, Sept. 5, 1930, 3 ♂ (Hubbell). Ohio: Castalia, Sept. 14, 1921, 1 ♀ (Crosby); Cedar Point, Sept. 14, 1921, 2 ♂, 1 ♀; Eaton, Sept. 3, 1930, 1 ♂ (Hubbell); Hocking Co., Sept. 10, 1931, 1 ♂ (Hubbell). *New York:* New York City, Aug. 15, 1927, 1 ♂, 1 ♀, (Lathan); Montauk, July 2, 1928, 2 ♂, 1 ♀ (Lathan); Orient, Sept. 3, 1925, 1 ♀ (Lathan); Fairhaven, July 31, 1932, 7 ♀ (Hughes); Fulton Co., Aug. 22, 1910, 1 ♀; Lake George, July 29, 1930, 2 ♀ (Crosby); Montour Falls, Sept. 8, 1917, 1 ♂, 4 ♀ (Crosby); Riverhead, Sept. 17 1913, 2 ♀ (Crosby); Ausable Chasm, Sept. 6, 1925, 1 ♂ (Leonard); Hornell, Sept. 18, 1925, 2 ♂; Richburg, Sept. 16, 1925, 1 ♀; Hunter, Aug. 5, 1923, 2 ♂, 1 ♀; Hague, Sept. 15, 1925, 1 ♂ (Leonard); Lake Keuka, 1 ♀; Silver Creek, Sept. 18, 1925, 1 ♂; Wellsville Sept. 15, 1925, 2 ♂; Kingston, fall 1908, 3 ♂; Riverhead, Sept. 1918 2 ♂; Forest Hills, Sept. 14, 1914, 1 ♂, 1 ♀; Wilmington, Aug. 20, 1916, 1 ♀;

vicinity of Ithaca, numerous specimens. *Pennsylvania:* Arendtsville, Aug. 21, 1928, 2 ♂, 2 ♀; Orangeville, Aug. 1932, 17 ♂, 14 ♀ (Hughes); Bushtown, Oct. 4, 1923, 1 ♀; Hazelton, 1925, 1 ♂, 1 ♀ (Dietz). *New Jersey:* Atlantic Co., Sept. 11, 1931, 1 ♂; Ridgewood, Aug. 14, 1927, 1 ♀ (Leonard). *Kansas:* Douglas Co., Sept. 8, 1930, 1 ♂, 9 ♀ (Hubbell). *Missouri:* Creve Coeur Lake, Aug. 4, 1926, 1 ♂; Columbia, July 1905, 1 ♂ (Crosby), 4 ♀ (Crosby); Darlington, 2 ♂; Hollister, Aug. 10, 1912, 6 ♂ (Knight); Maryville, Aug. 1905, 1 ♂ (Crosby). *Kentucky:* Quicksand, Aug. 1925, 5 ♂, 5 ♀ (Funkhauser). *Virginia:* South Hill, Oct. 26, 1923, 1 ♂; Nottoway River, Oct. 23, 1923, 4 ♂, 1 ♀; Buchanan, Oct. 6, 1923, 1 ♀. *Oklahoma:* Newkirk, Oct. 28, 1907, 1 ♂; Comanche, 1 ♂. *Arkansas:* Murfreesboro, 1 ♂. *Tennessee:* Bristol, Oct. 5, 1926, 3 ♂, 2 ♀; Gatlinburg, Oct. 7, 1926, 2 ♂. *North Carolina:* Raleigh, Oct. 26, 1923, 1 ♀; Blowing Rock, Oct. 10, 1923, 1 ♂ (Crosby); Winston-Salem, Aug. 8, 1923, 1 ♂, 1 ♀; Oteen, Oct. 15, 1923, 1 ♂; Grandfather Mountain, Oct. 12, 1923, 1 ♀. *South Carolina:* Beaufort Co., Oct. 3, 1930, 1 ♂ (Hubbell). *Louisiana:* Jennings, 1 ♀. *Mississippi:* Hattiesburg, Nov. 19, 1931, 6 ♂, 1 ♀ (Dietrich); Agricultural College, Oct. 1916, 6 ♂, 1 ♀ (Bailey). *Georgia:* 1 ♂.

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PLATE XXXI

FIGURES

1. *Leiobunum peninsulare* sp. nov. Dorsal view of penis.
2. *Leiobunum auruginosum* Crosby and Bishop. Dorsal view of penis.
3. *Leibunum serratipalpe* Roewer. Lateral view of penis.
4. Same. Dorsal view of penis.
5. *Leiobunum vittatum* (Say). Dorsal view of penis.
6. *Leiobunum nigropalpi* (Wood). Dorsal view of penis.
7. *Leiobunum relictum* sp. nov. Dorsal view of penis.
8. *Leiobunum bimaculatum* Banks. Dorsal view of penis.
9. *Leiobunum verrucosum* (Wood). Dorsal view of penis.
10. *Leiobunum longipes* Weed. Dorsal view of penis.
11. *Leiobunum townsendi* Wood. Dorsal view of penis.
12. *Leiobunum exilipes* (Wood). Dorsal view of penis.
13. Same. Dorsal view of tip of penis showing variation.
14. *Leiobunum cretatum* Crosby and Bishop. Dorsal view of penis.

PLATE XXXI

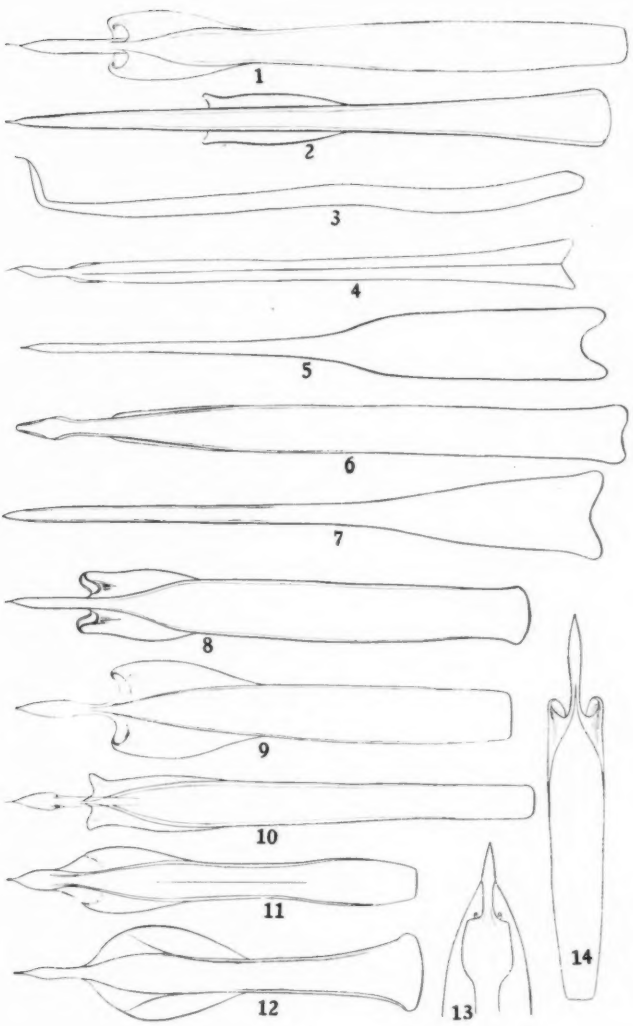


PLATE XXXII

FIGURES

15. *Leiobunum crassipalpe* Banks. Dorsal view of penis.
16. *Leiobunum calcar* (Wood). Lateral view of penis.
17. Same. Dorsal view of penis.
18. *Leiobunum bicolor* (Wood). Dorsal view of penis.
19. *Leiobunum uxorium* Crosby and Bishop. Dorsal view of penis.
20. *Leiobunum flavum flavum* Banks. Dorsal view of penis.
21. *Leiobunum speciosum* Banks. Dorsal view of penis.
22. *Leiobunum crassipalpe* Banks. Dorsolateral view of shaft of penis.
23. Same. Cross section of shaft of penis.
24. *Leiobunum depressum* sp. nov. Dorsal view of penis.
25. *Leiobunum paessleri* Roewer. Dorsal view of penis.
26. *Leiobunum nigripes* Weed. Dorsal view of penis.
27. *Leiobunum politum* Weed. Dorsal view of penis.
28. *Leiobunum formosum* (Wood). Dorsal view of penis.
28. *Leiobunum flavum leiopenis* subsp. nov. Dorsal view of penis.
29. *Leiobunum paesskeri* Roewer. Ventral view of tip of penis.
30. *Leiobunum politum* Weed. Cross section of shaft of penis at point of compression.

PLATE XXXII

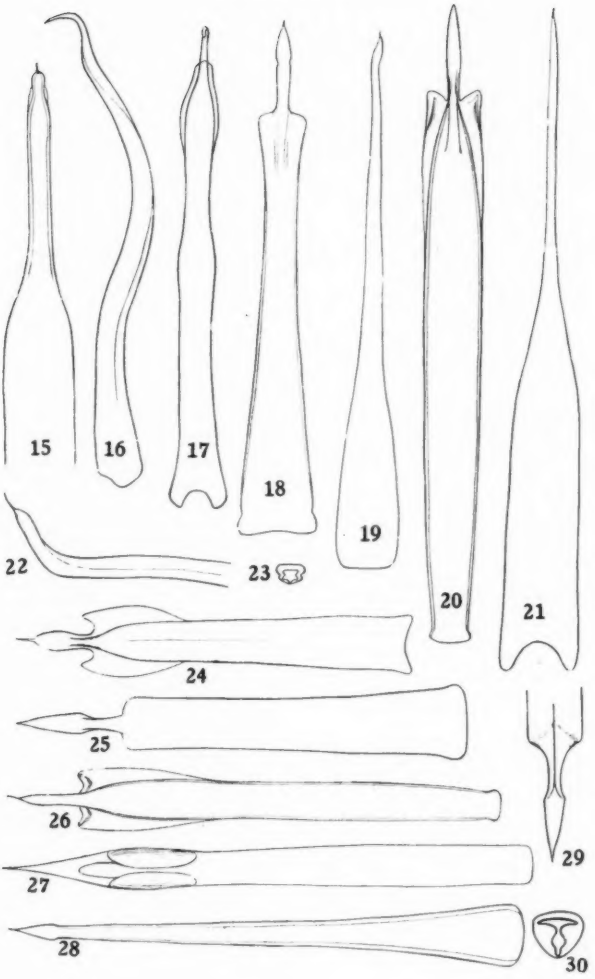
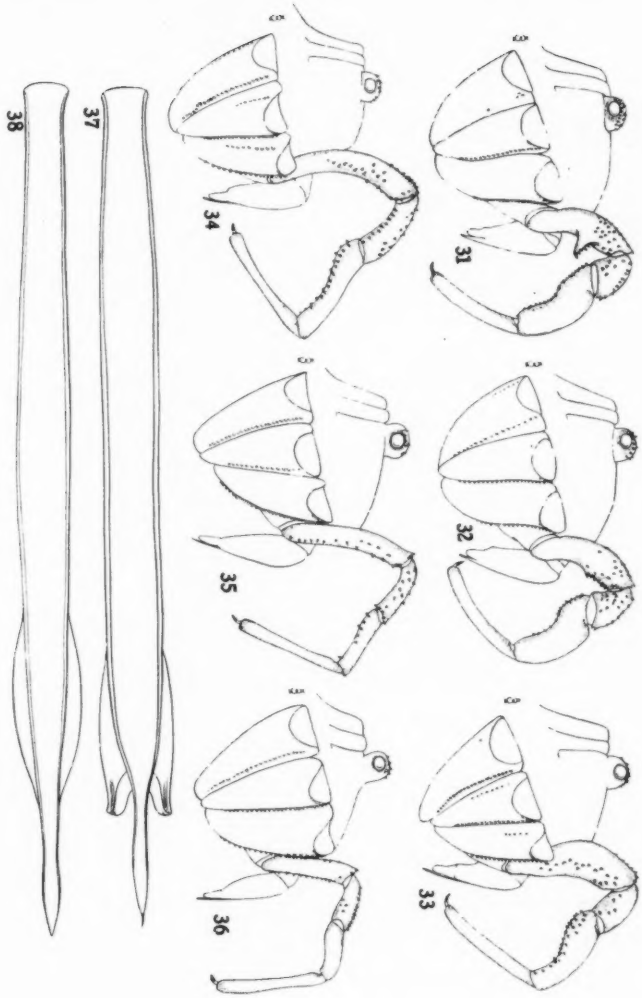


PLATE XXXIII

FIGURES

31. *Leiobunum calcar* (Wood). Lateral view of palpus and carapace.
32. *Leiobunum serratipalpe* Roewer. Lateral view of palpus and carapace.
33. *Leiobunum crassipalpe* Banks. Lateral view of palpus and carapace.
34. *Leiobunum vittatum* (Say). Lateral view of palpus and carapace.
35. *Leiobunum uxorium* Crosby and Bishop. Lateral view of palpus and carapace.
36. *Leiobunum cretatum* Crosby and Bishop. Lateral view of palpus and carapace.
37. *Leiobunum ventricosum hyemale* Weed. Dorsal view of penis.
38. *Leiobunum ventricosum floridanum* subsp. nov. Dorsal view of penis.

PLATE XXXIII



A NEW FOUR-HORNED MOSSMITE (ORIBATOIDEA-ACARINA)

ARTHUR PAUL JACOT

The term Oribatella was coined by Nathan Banks in 1895 but was not typed until 1908 when Antonio Berlese appointed *O. quadridentata* Banks 1895 to function as such. Thus constituted this genus is one of the most highly specialized of the winged mossmites but contrary to the Galumninae this group specialized not only on huge lamellae but on spines. For instance, each lamella bears two, long, slender spines, making a total of four. These four parallel spines form such a conspicuous freize that species have been named four-horned and four-toothed. In fact, "the four-horned mossmites" is an excellent popular term, as these structures are both conspicuous and unique.

Tectopedia I are developed as long blades running as far forward as the lamellar horns and their distal ends are frayed out in several prominent teeth. The rostrum is drawn out as a high prow, the dorsal end of which is developed out as a short spike while the lower end is similarly extended as a pair of blunt teeth which extend backward as a ridge, one on each side of the edge of the mouth-opening. The bristles of the head and prothorax are long, stout, stiff and densely burred to barbed. Finally, the anterior two pairs of legs each bear two stout, burred, medium long spines. These spines project prominently when the legs are folded into their recesses. Thus the whole anterior end of the animal resembles a most prickly looking little burr, more so than any other genus of Oribatoidea known to me.

One of its further characteristics is the unusually anterior insertion of legs I and their consequent position when retracted. They are inserted at the *anterior* end of the huge tectopedia II, being widely separated from legs II! When at rest the femur lies straight back in the tectopedium and the tibia and tarsus are then directed forward between the huge lamellae and tectopedia I. It is from between these two blades that the tibial spine projects, while the genual spine is close to the pseudostigma. The claws thus project between the distal ends of the lamellar prongs and the teeth of tectopedia I to add to the general spiny appearance of the facade. Legs II likewise are folded up under the anterior edge of the pteromorphae and the tibia and tarsus bent down into posterior edge of tectopedia II so that the two spines project beyond the edge of this tectopedium. Tibiae IV each possess a stout burred spine which projects from the ventral edge of the pteromorphae when the legs are withdrawn. Thus each pteromorpha is lined with these vicious looking spikes. As though all this were not sufficient, tectopedia IV are prolonged forward each as a long, pointed spine which passes ventrad of trochanters III and of tectopedia III.

Another striking character is that the lamellae are free from each other

(though usually touching at their widest points), except at the very base of the prothorax where they are either joined by a slender bridge or separated by a conelike peg, thus differing markedly from Achipteria.

The labium is also strikingly differentiated in that its distal end is greatly thickened and bent downward and backward as stout, protruding lips. Distad of these lips is a pair of slender transverse plates with a bristle at each end. I know of no other genus of mossmites with such development.

Finally, the sides of the cephalon (the genae) project laterad and ventrad as a bay-window, and anteriad as a blunt prow which extends beyond tectopedia II and appear somewhat as a continuation of tectopedia II (Figures 1 and 5).

The various species are not nearly as common as the large-winged mossmites (Galumninae) and are found principally on decaying wood of the forest floor, under bark of fallen or standing trees, and probably under the bark-scales and in rot-pockets of living trees. They may be gathered by hand picking or by drying out moist, decayed wood by spreading it out on a drying funnel.

The following species is new:

Oribatella brevicornuta sp. nov.

Figure 9

Diagnostic characters: Horns of lamellae much shorter than blade of lamellae, the base of the horns broad so that they are, compared with other species short and stout; the mesal horn more slender than the lateral; lamellar bristles inserted nearer mesal than lateral edge of lamellae; notogastral bristles rather long, all of equal caliber, fairly straight, not stout; spine of genuals I and II extending to base of tibial spine.

Description: Rather than give a detailed description, I will make a careful comparison with the common species of Europe (*Oribatella calcarata;* 3, fasc. 2/13), detailed figures of which are now presented for the first time, based on material from the type locality (Regensburg in Bavaria)*.

Size: Total median length of body (fifteen specimens measured) 0.47 (0.52) 0.57 mm., breadth of ventral plate 0.3 mm. The corresponding figures for *O. calcarata* are 0.48 (0.51) 0.54 and 0.3 mm. The reason for greater variation in size in the American species may be due to specimens coming from five states instead of one locality. Lamellae as above described, surface pebbled, in either species lateral edge may have auxiliary teeth, in which case the two lamellae of the same individual invariably differ in the position and size of these teeth, the condition illustrated in Figure 9 (right lamella) is unusual, Figure 10 illustrates another unusual lamella; interlamellar bridge well developed, extending anteriad of attachment area of lamellae; in *O. calcarata* this bridge is represented by a raised, conical process; proximomesal spur of lamellae distant from anterior end of notogaster, close to it in *O. calcarata;* lamellar, rostral, and interlamellar bristles similar in the two species, interlamellar bristles the slenderest and most finely burred, lamellar bristles quite

* Secured through a grant from the Elizabeth Thompson Science fund.

stout, quite coarsely burred, in *O. calcarata* similar to pseudostigmatic organs but more coarsely burred; pseudostigmatic organs very similar, if anything more blunt and slightly broader, finely burred (Figure 3); tectopedia I with a distinct porose area close to dorsoproximal angle, held more vertically than in *O. calcarata* so that lateral edge in dorsal aspect seems more dense and the teeth, which are actually fewer, are less evident (compare Figures 4 and 9) the whole tectopedium thus appearing more pointed in dorso/ventral aspects; dorsal spur of rostrum somewhat more blunt; tectopedia II somewhat shorter, with a distinct, fine bristle (represented by a defunct insertion in *O. calcarata*, the tectopedium finely corrugated on lateral face), thin spot (represented by a curved line in figures) smaller and more defined; ventral side of cephalon somewhat angled, not prominently flaring out as in *O. calcarata* where it resembles an accessory tectopedium.

Notogaster broader, more quadrate, posterior end broad, almost truncate; bristles longer, straighter, more coarsely (though not coarsely) burred; third bristle of lateral rows (c3) in normal position, in *O. calcarata* it has moved into line with the middle rows (between the second and third), third (or fourth) bristles of mesal rows (the anterior two or three being absent in this genus) normal, more closely spaced (stout, suberect in *O. calcarata*, a distinctive characteristic mentioned by Koch), posteriormost bristles not so far down and thus more conspicuous in dorsal aspect; porose areas somewhat smaller; pteromorphae with anterior edges corrugated in both species, the anteroventral angle pointed in both, more apiculate in *O. calcarata* and with transverse plicae just above it (Figure 1).

Ventral plate with anal aperture, as usual in this genus, distant from posterior edge, anterolateral wings merging into tectopedia II; tectopedia III squarish, the bristles neither coarse nor coarsely burred; tectopedia IV more elongate than in *O. calcarata*, the bristle long, similar to notogastral bristles (in *O. calcarata* it is like a leg spine); apodemata rather similar; lacunae less distinct; sternal bristles more approximate; all ventral plate bristles much longer, quite distinct, similarly situated, except that of parasterna IV which is more laterad; genital aperture with anterior edge more convex, marginal bristles forming a crescent with cover bristles 1 and 2, bristle 2 more anterior, bristles 3 and 4 more distant; anal region quite similar, postanal bristles more distant.

Legs similar in the two species but in *O. calcarata* the bristles and spines are all shorter, not reaching as far as in the American species. Ungues strongly triheterohamate, the lateral and mesal nails flattened. Tarsi I with dorsoproximal quartette reduced to three bristles (Figure 6) though the fourth insertion is present (Figure 7); ventroproximal bristle quite smooth, second ventral long-ciliate, third and fourth ventrals barely ciliate thus the second stands out in sharp contrast with the others; other leg bristles quite usual for the higher oribatids, except for the replacement of the two mesal bristles by the heavy spines. The femora have two dorsal bristles near distal end, nearly on same transverse plane (Figure 7). These are usually difficult to make out in lateral aspect. Genuals with a short ventrodistal spur. Legs II with femoral

flange slightly broader (higher), dorsoproximal bristle of femora more distal, at broadest part of segment; spines longer than in legs I.

Legs IV (Figure 8) highly specialized. Trochanters somewhat triangular, the lateral face developed as a huge flange which extends anteriorly (proximally) as well as slightly ventrodistally, both body of segment and flange finely, irregularly corrugated; flange higher than body of segment; a single, short, lateral bristle inserted on ventro distal angle of flange. Femora compressed, oblong, with a flange at least half height of segment, the proximal corner overlapping flange of trochanter, dorsal face with a stout, burred spinelike bristle inserted at center of segment, a fine bristle inserted near distal end of flange. Genuals cuneiform with a small flange, a ventrodistal spur, and the usual dorsodistal and ventrodistal bristles, the latter frequently appearing as a continuation of the spur. Tibiae cylindrical with a short, curved pedicel, dorsal face with a crest or else very much thickened walls; lateral face with a rather long, stout, spinelike bristle, burred in at least two longitudinal rows; ventral face bristle barely extending beyond end of segment, appressed-ciliate; ventrodistal and dorsal bristles smooth. Tarsi normal for the higher Oribatidae, the proximoventral bristles pauciciliate.

Legs III similar to normal higher Oribatidae; trochanters flangeless, femora with very slender flange along ventrodistal edge; other characters not noteworthy.

Eggs: Both species were found with a maximum of four eggs at a time.

Material examined: New York: Five specimens from Buttermilk Creek, Ithaca; taken May 21st by Nathan Banks, slide 26B81d. Six specimens from twigs and under bark, Danby to West Danby; taken May 19, 1917, slides 171Oo1a, -b, and -c *(cotypes)*. One specimen from upper two inches of layer of chestnut oak, basswood, and mountain maple leaves, on steep south, rocky, slope of glen two miles north of Cornell campus; taken June 8th, 1928 by Robert Daniel Harwood, lot 845 sub 87A, slide 4 (Cornell Univ. Coll.). *Connecticut:* Four specimens from old rails, old branches, and wood chips, old apple orchard, East Village, Monroe; taken August 4th, 1932, slide 3229o2.

Oribatella brevicornuta plummeri subsp. nov.

Figure 13

Differs from the species in the interlamellar gap which is roundish to pentagonal instead of elongate (compare Figures 9 and 11 with 13) thus making the lamellar bridge much longer, and causing the mesal horns to overlap; notogastral bristles much shorter, strongly curved ventrad; bristles c3 more nearly in line with b2 and b3, that is, more like *O. calcarata;* sides of camerostome more slender, not angular; anterior sternal bristles more approximate; nuchal (parasterna I) bristles more remote, thus leaving a much greater distance between nuchal and anterior sternal bristles; middle sternal bristles more remote, thus sharply contrasting with anterior sternal bristles; paranal bristles near anterior corner of anal aperture.

Material examined: Seven specimens from deep layer of old leaves, Plum-

mer's Island, Maryland; collected by H. S. Barber, slides 307o2 to 307o5 *(cotypes)*. Eleven specimens from leaf mould, Plummer's Id., Md.; taken March 2nd 1924 by August E. Miller, slides 4 and 4.1 (Miller coll.).

Oribatella brevicornuta extensa subsp. nov.

Figure 12

Differs from the species in the lamellar cusps which are quite long and slender, the mesal slightly shorter; in the more approximate bristles b2, which are almost as approximate as a2, these four bristles forming the corners of what is nearly a square; and in the more slender camerostome sides.

Although the lamellar horns are so much longer and more slender, the basal specific plan is retained in that the bristle is inserted slightly mesad of center of lamella, and the base of the lateral horn is broader, with longer shoulder than the mesal horn.

Material examined: Six specimens from shore twelve miles from south point of North Beach, St. Augustine, *Florida;* taken April 1st 1928, by Edgar F. Grossman, slides G63011 to G63015 *(cotypes)*. One specimen from fallen leaves under small elders, half to three quarter inch mulch, rather damp, horticultural grounds, Gainesville, Fla.; taken February 29th 1928 by Grossman, slide G29011. Two specimens from fallen oak leaves, upper edge of Devil's Mill Hopper, Gainesville, Fla.; taken April 24th 1928 by Grossman, slide G76011. *Ohio:* One specimen (out of ninety lots) from bluegrass sod, Mt. Logan, Chillicothe; taken March 9th 1925 by August E. Miller, slide 32M139o. Thirty-one specimens from feltlike fungus under rotten stump, South Salem; taken May 7th 1924 by Miller, slide 32M104o. *Indiana:* Five specimens from fallen leaves, deciduous woods, Lafayette; taken November 28th 1932 by R. A. Ragains, slides 33InA102, ssInA205, 33InA1n1, 33InB1n. *Illinois:* One specimen from under board or log, Arcola; taken June 20th 1906 by H. E. Ewing, slide 26EwB1. One specimen from under log, pastured woods, three miles southeast of Arcola; taken July 4th 1906 by Ewing, slide 26Ew147. Seventy-eight specimens from lower side of sound, overturned, oak stump, supporting a luxuriant growth of very short, grey, feltlike fungus, five miles west of Pittsfield; taken July 18th 1927 by Miller, slide 32M113o. Thirty-three specimens from under side of board lying on ground in open woods, Sidney; taken June 25th 1926 by Miller, slides 32M501 and -02. One specimen from under side of fallen, moist log, Dodson's Woods, Urbana; taken August 18th 1926 by Miller, slide 32M20. One specimen from under loose bark of untopped, fallen white-oak in northeast corner of Dodson's Woods, sunny exposure, two feet from ground; taken June 6th 1927 by Miller, slide 32M125o. Nineteen specimens from under loose bark of fallen black-oak log near margin of Dodson's Woods, Urbana; taken June 7th 1927 by Miller, slides O-8.1-27 and O-8.2-27 (Miller coll.). One specimen from under loose, moist bark on fallen log, Brownfield's Woods, Urbana; taken May 1st 1926 by Mrs. Miller, slide O-16-26 (Miller coll.). *Iowa:* One specimen from Ames; taken fall of 1932 by H. B. Mills, slide 333on. *Virginia:* Six speci-

mens from mould on decaying wood and in same wood, Great Falls; taken September 9th by Banks, slides 26B117a and -b.

The specimens from Ohio to Illinois and Virginia are not quite typical in that the interlamellar gap is elongate (like the species) instead of ovate (Figure 12), but as this is the only difference I do not regard these individuals from the northern edge of the Austral Life Zone as representing a distinct race but rather as transitional to the Transitional Life Zone form (the species).

Habitat: From the above records of occurrences it is evident that this species is at home on decayed wood. Although they bear a few spores on their bodies, I have not noted spores in their stomachs, except as accidental.

This is the largest and commonest species of the genus in the eastern United States. Individuals of this species and subspecies have been referred by Banks and Ewing to *O. calcarata*.

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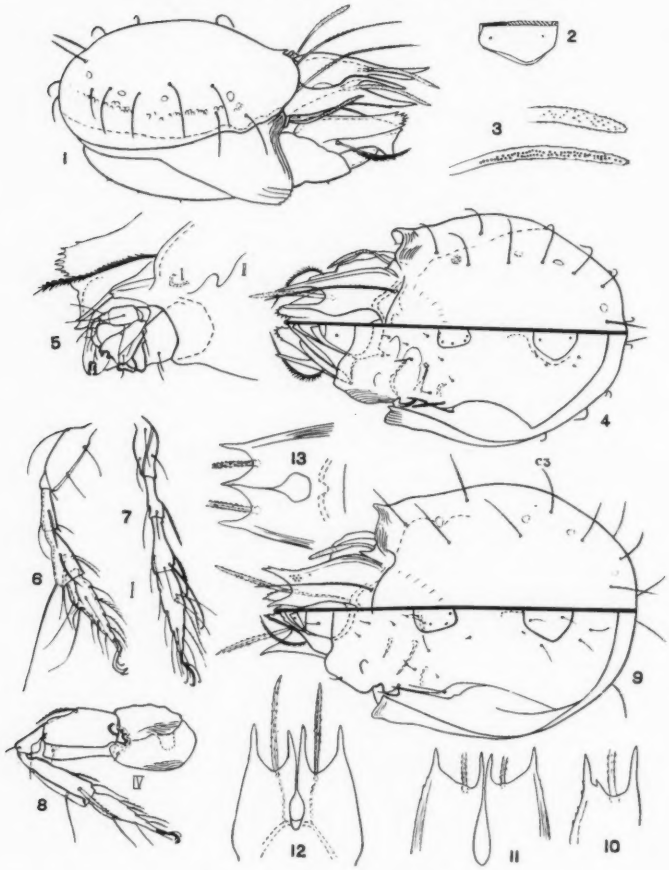
FEDERAL BLDG.,
ASHEVILLE, N. C.



Oribatella calcarata (Koch), adult

(1) Lateral aspect, somewhat dorsal, legs and mouth parts omitted; ratio x120. (2) An anal cover; ratio x200. (3) Pseudostigmatic organ head, the lower showing oil globules; ratio x440. (4) Dorso/ventral aspects, legs and mouth parts omitted; ratio x120. (5) Labiorostral region; ratio x200. (6) Legs I, lateral aspect; ratio x200. (7) Legs I, dorsal aspect; ratio x200. (8) Legs IV, lateral aspect; ratio x200.

Oribatella brevicornuta sp. nov., adult

(9) Dorso/ventral aspects, legs and mouth parts omitted; ratio x120. (10) A lamella, showing a variation (one side only); ratio x200. (11) Lamellae of an unusual individual ; ratio x150.

(12) *Oribatella brevicornuta extensa* subsp. nov., adult, lamellae; ratio x150.

(13) *Oribatella brevicornuta plummeri* subsp. nov. adult, lamellae; ratio x150.

A CHECK-LIST OF OHIO ALGAE
WITH ADDITIONS FROM THE CINCINNATI REGION

LOIS C. LILLICK AND ISABELLA M. LEE

This check-list is the third of such papers to appear in Ohio. In 1893 W. A. Kellerman of Ohio State University included a section on Algae in his "Catalogue of Ohio Plants." This was the first attempt to assemble in published form the algal flora of the State as a whole. In this paper Kellerman listed 151 species and varieties, distributed in the following groups: Chlorophyceae 111, Cyanophyceae 22, Characeae 8, Rhodophyceae 6, Euglenophyceae 1, Heterokontae 3; the locality and the collector were given for each species. In 1902 Dr. Kellerman published a second list in his "Proposed Algological Survey of Ohio." Here 169 species and varieties were included, but no information concerning the collections was given. Although Dr. Kellerman hoped, by his paper, to arouse interest in the collection of a state algal flora with a view toward future publication of the survey, no such paper was ever produced.

The present list represents 709 species and varieties in the following groups: Cyanophyceae 118, Chlorophyceae 500, Rhodophyceae 8, Dinophyceae 5, Chrysophyceae 2, Heterokontae 12, Characeae 17, Euglenophyta 47. This represents an increase of 540 forms, distributed in all of the groups of fresh-water algae.

The literature reviewed on the algae reported for Ohio includes all published papers known to the writers, a total of 48.[1] The earliest record for the state was a list of Characeae—then considered higher plants—by Dr. J. L. Riddell in 1834. The next record, also of a Chara, was given in 1844 by Dr. Alexander Braun. In 1852 a third paper on Charas was prepared by J. Clark. About twenty years elapsed before the next publication on algae appeared—H. C. Beardslee, 1875. From this time on the reports increased in number and in groups covered, culminating in Dr. Kellerman's check-list of 1893.

Up to the present time much of the work has centered around the Granville, the Columbus and the Lake regions. In the present paper a preliminary survey of the Cincinnati region has been undertaken. The area included extends west to the Big Miami River, east to Adams Co., and in Kentucky, Boone, Kenton, and Campbell counties. Dr. G. B. Twitchell made rather extensive collections over a period of years, in the immediate vicinity of Cincinnati, but never published his reports. They were, however, included in Kellerman's 1893 paper.

[1] Papers which appeared after June, 1934 have not been included.

The present personal survey has resulted in 54 new state records, Cyanophyceae 34, Chlorophyceae 16, Rhodophyceae 1, Dinophyceae 1, Heterokontae 1, and Euglenophyta 1. In the check-list the locality, collector, and date of collection is given for each species. The collections of the writers are distinguished from those of the others by the omission of the collector's name, except in the case where such forms were brought in by persons other than the writers, the name of the collector then being given in parentheses. New records of species are indicated by one star, new records of genera by two stars. Synonomy has been checked in every case; where synonyms are substituted in accordance with an authority on the particular group, the name under which the original collection was recorded is placed in parentheses.

There are 13 species or varieties reported from Ohio, or less than three per cent. of the entire list, which do not appear in modern literature. These are designated by a +. All were reported in or before 1905. Two of this number were described as new species. Comparatively few of the early records have not been substantiated by subsequent collections. Certain of the earlier papers recording algae from Ohio were not included by Dr. Kellerman in 1893; these are, however, accounted for in the present paper.

Diatoms are excluded from this paper, as are also all records known to others, but not as yet published. Many algal surveys have been made in the past few years, the results of which will doubtless be published in the near future, however, no account of these papers can be given here. It is exceedingly probable that through these papers the known algal flora of the state will be nearly doubled.

Various authorities were used for the different groups as follows: Cyanophyceae, Tilden, Geitler, and Gomont; Rhodophyceae, Pascher, Forti; Charophyta, Migula, Engler and Prantl, Groves and Bullock-Webster, and Jones; Flagellates, Pascher, Lemmermann, Schilling, Walton, G. M. Smith, and West and Fritch; Chlorophyceae, (in part) Collins, DeToni, Engler and Prantl. Authorities for the special groups of Chlorophyceae include: Zygnemales, Pascher and Borge, G. M. Smith, and West and Fritsch; Oedogoniaceae, Tiffany; Vaucheriaceae, H. J. Brown; Chaetophoraceae and Ulotrichaceae, Heering, and Hazen; Protococcales, Pascher, Lemmermann, Brunnthaler; Siphonales, Heering. In compiling this check-list the classification suggested by G. M. Smith has been followed.

All specimens collected in the present survey of the Cincinnati region are deposited in the herbarium of the University of Cincinnati. The material upon which the other papers were based, has in many cases not been preserved, thus detracting somewhat from the value of the record.

The authors wish to acknowledge the assistance of Dr. J. H. Hoskins of the University of Cincinnati, upon whose suggestion and under whose guidance the work was carried out; and of Dr. M. A. Howe of the New York Botanical Garden, for helpful suggestions and criticism of the paper. Gratitude is also extended to all other members of the department who have made collections and have in other ways lent valuable aid in this project.

I. CHECK LIST OF OHIO ALGAE

Myxophyceae

CHROOCOCCALES

Chroococcaceae

Aphanocapsa Nägeli

**A. elachista* W. & G. S. West. Near Seven Caves, Highland Co., (Cooke, Aug. 1932).

A. pulchra (Kütz.) Rabenh. Lake Erie, Coyle, 1930.

**A. Zanardinii* (Hauck) Hansg. Near Seven Caves, Highland Co., (Cooke, Aug. 1932).

Aphanothece Nägeli

***A. Naegelii* Wartm. Near Addyston, Hamilton Co., (Hoskins, Oct. 1933).

Chroococcus Nägeli

C. limneticus Lemm. Lake Erie, Snow, 1902; Coyle, 1930; Tiffany and Ahlstrom, 1931.

var. *carneus* (Chodat) Lemm. Lake Erie, Tiffany and Ahlstrom, 1931.

var. *distans* G. M. Smith. Lake Erie, Coyle, 1930; Tiffany and Ahlstrom, 1931.

var. *purpureus* (Snow) Tiffany & Ahlstrom. Lake Erie, Snow 1902 (*Chroococcus purpureus* Snow); Tiffany and Ahlstrom, 1931.

var. *subsalsus* Lemm. Lake Erie, Tiffany and Ahlstrom, 1931.

C. pallidus Nägeli. Lake Erie, Snow, 1902.

**C. tenax* (Kirchn.) Hieron. Beaver Pond, Adams Co., April 1933.

C. turgidus (Kütz.) Nägeli. Brush Lake, Champaign Co., Riddle, 1905. Ohio river drainage streams, Coyle, 1930. Near Seven Caves, Highland Co., (Cooke, Aug. 1932).

C. varius A. Br. Ohio River drainage streams, Coyle, 1930.

Coelosphaerium Nägeli

C. Kuetzingianum Nägeli. Lake Erie, Snow, 1902; Riddle, 1903; Coyle, 1930. Buckeye Lake, Tiffany 1921. Mirror Lake, Columbus, (Runyon, Sept. 1933).

**C. minutissimum* Lemm. Kennedy Heights, Cincinnati, Mar. 1934.

C. Naegelianum Unger. Lake Erie; Ohio River drainage streams, Coyle, 1930.

Gloeocapsa Kützing

**G. atrata* (Turp.) Kütz. Near Seven Caves, Highland Co., (Cooke, Aug. 1932).

G. gelatinosa Kütz. Lake Erie, Coyle, 1930.

G. granosa (Berk.) Kütz. Lake Erie, Snow, 1902, (*G. fenestralis* Kütz). Near Seven Caves, Highland Co., (Cooke, Aug. 1932). Beaver Pond, Adams Co., March 1933.

G. punctata Nägeli. Lake Erie, Snow, 1902. Near Seven Caves, Highland Co., (Cooke, Aug. 1932). Beaver Pond, Adams Co., March 1933.

Gloeothece Nägeli

G. dubia (Wartm.) Geitl. Lake Erie, Coyle, 1930, *(Gloeocapsa dubia* Wartm.). Beaver Pond, Adams Co., Mar. 1933.

G. fusco-lutea Nägeli. Beaver Pond, Adams Co., Mar. 1933.

G. membranacea (Rabenh.) Bornet. Near Seven Caves, Highland Co. Beaver Pond, Adams Co., March 1933. Greenhouse, University of Cincinnati, March 1934.

G. montana Kütz. Near Addyston, Hamilton Co., (Hoskins, Sept. 1933).

G. rupestris (Lyngbye) Born. Near Seven Caves, Highland Co., (Cooke, Aug. 1932.)

Gomphosphaeria Kützing

G. aponina Kütz. Brush Lake, Champaign Co., Riddle, 1905.

form. *aurantiaca* (Bleisch) Forti. Lake Erie, Snow, 1902.

G. lacustris Chodat. Lake Erie, Coyle, 1930; Tiffany and Ahlstrom, 1931. Ohio River drainage streams, Coyle, 1930.

G. rosea (Snow) Lemm. Lake Erie, Snow, 1902, *(Coelosphaerium roseum* Snow).

Marssoniella Lemmerman

M. elegans Lemm. Lake Erie, Tiffany and Ahlstrom, 1931.

Merismopedia Meyen

M. convoluta Bréb. Lake Erie, Riddle, 1903; Tiffany and Ahlstrom, 1931. Brush Lake, Champaign, Co. Riddle, 1905.

M. elegans A. Br. Lake Erie, Snow, 1902. Chippewa Lake, Tiffany, 1921. Ohio River Drainage streams, Coyle, 1930.

M. glauca (Ehrenb.) Nägeli. Lake Erie, Snow, 1902; Riddle, 1903; Coyle, 1930. Brush Lake, Champaign Co., Riddle, 1905. Buckeye Lake, Loramie Lake, St. Mary's Lake, Chippewa Lake, Tiffany, 1921. Ohio River drainage streams, Coyle, 1930. Greenhouse, University of Cincinnati, Feb. 1934. Lake Isabella, Hamilton Co., Oct. 1933.

M. nova Wood. Lake Erie, Vorce, 1881.

M. punctata Meyen. Lake Erie, Snow, 1902; Coyle, 1930. Ohio River drainage streams, Coyle, 1930. Big Miami River, North Bend, (Fink, Aug. 1932).

var. *minor* (Wille) Tiffany and Ahlstrom. Lake Erie, Tiffany and Ahlstrom, 1931.

M. tenuissima Lemm. Lake Erie, Snow, 1902; Coyle, 1930. St. Mary's Lake Chippewa Lake, Tiffany, 1921. Ohio River drainage streams, Coyle, 1930

†*M. violacea* Kütz. Lake Erie, Snow, 1902.

Microcystis Kützing

M. aeruginosa Kütz. Lake Erie, Snow, 1902, *(Clathrocystis aeruginosa* Henfr.); Coyle, 1930. Ohio River drainage streams, Coyle, 1930.

M. Flos-aquae (Wittr.) Kirchn. Lake Erie; Ohio River drainage streams, Coyle, 1930.

M. ichthyoblabe Kütz. Lake Erie, Snow, 1902, *(Polycystis ichthyoblabe* Kütz.).

M. marginata (Menegh.) Kütz. Buckeye Lake; New Reservoir, Akron, Tiffany, 1921.

M. pulverea (Wood) Fort. Lake Erie, Coyle, 1930.
var. *incerta* (Lemm.) Crow. Lake Erie, Coyle, 1930 *(M. incerta* Lemm.).

Synechococcus Nägeli

**S. elongatus* Nägeli. Kennedy Heights, Cincinnati, April 1934. Greenhouse, University of Cincinnati, Mar. 1934.

Tetrapedia Reinsch

T. Reinschiana Arch. Buckeye Lake, Tiffany, 1921.

HORMOGONIALES

Oscillatoriaceae

Lyngbya Agardh

L. aerugineo-caerulea (Kütz.) Gom. Lake Erie, Snow, 1902. *(Oscillatoria aerugineo-caerulea* Kütz.).

L. aestuarii Lieb. Ohio River drainage streams, Coyle, 1930.

L. Bergei Smith. Ohio River drainage streams Coyle, 1930. Addyston, Hamilton Co., Aug. 1933.

L. (?) cryptovaginata Schkorb. Ohio River drainage streams, Coyle, 1930.

L. Kützingiana Kirchn. Ohio River drainage streams, Coyle, 1930.

L. (?) *lutea* (Ag.) Gom. Ohio River drainage streams, Coyle, 1930.

L. nigra Ag. Mansfield, Walton, 1930.

Microcoleus Desmazieres

M. chthonoplastes Thuret. Columbus, Eldridge in Kellerman, 1893, *(M. gracilis* Hass.). Kellerman, 1902, *(M. gracilis* Hass.). Lake Erie, Snow, 1902, *(M. anguiformis* Harv.).

M. lacustris (Rabenh.) Farlow. Brush Lake, Champaigne Co., Riddle, 1905.

Oscillatoria Vaucher

**O. Agardhii* Gom. Big Miami River, North Bend, (Fink, Aug. 1932).

O. amoena Gom. Ohio River drainage streams, Coyle, 1930.

O. anguina (Bory) Gom. Cuyahoga Co., Watson, 1900. Kellerman 1902.

O. animalis Ag. Cincinnati, Twitchell in Kellerman, 1893. *(O. elegans* Ag.). Kellerman, 1902, *(O. elegans* Ag.). Brush Lake, Champaigne Co., Riddle, 1905, *(O. elegans* Ag.).

**O. angustissima* W. & G. S. West. Cincinnati, Oct. 1933.

**O. Boryana* Bory. Burnet Woods Lake, Cincinnati, Oct. 1933.

O. brevis (Kütz.) Gom. Ohio River drainage streams, Coyle, 1930. Greenhouse, University of Cincinnati, Nov. 1933.

O. chalybea Mertens. Lake Erie, Snow, 1902. Addyston, Hamilton Co., Aug. 1933.

**O. formosa* Bory. Near Symmes, Hamilton Co., (Cooke, Nov. 1933).

**O. irrigua* Kütz. Near Cincinnati, 1933. Beaver Pond, Adams Co., Apr. 1933.

O. laetevirens (Crouan) Gom. Ohio River drainage streams, Coyle, 1930.

O. limosa Ag. Cincinnati, Twitchell, 1885. Columbus, greenhouse, Kellerman and Eldridge in Kellerman, 1893, *(O. Froelichii* Kütz.). Cuyahoga Co., Watson, 1900, (also as *O. Froelichii fusca* Kirchn.). Kellerman, 1902, *(O. Froelichii* Kütz. and *O. Froelichii fusca* Kirchn.). Lake Erie, Snow, 1902, *(O. Froelichii* Kütz.); Coyle, 1930. Brush Lake, Champaign Co., Riddle, 1905, (also as *O. Froelichii* Kütz.). Mirror Lake, Columbus, Kraatz, 1921. Warren, Walton, 1930. Ohio River drainage streams, Coyle, 1930. Big Miami River, North Bend, (Fink, Aug. 1932). Greenhouse, University of Cincinnati, Sept. 1933.

O. nigra Vauch. Painsville, Beardslee, Cincinnati, Twitchell; Lima, Kellerman, all in Kellerman, 1893. Kellerman 1902.

O. princeps Vauch. Columbus, Bogue; Cincinnati, Twitchell, in Kellerman, 1893. *(O. Imperator* Wood). Cuyahoga Co., Watson, 1900. Kellerman, 1902, (also as *O. Imperator* Wood). Lake Erie, Snow, 1902, *(O. Imperator* Wood). Ohio River drainage streams, Coyle, 1930.

O. sancta (Kütz.) Gom. Cincinnati, Twitchell in Kellerman, 1893, *(O. major* Vauch.). Kellerman, 1902, (also as *O. major* Vauch.). Ohio River drainage streams, Coyle, 1930.

O. simplicissima Gom. Cincinnati, Walton 1930.

O. splendida Grev. Columbus, Kellerman, 1893, *(O. tenerrima* (Kütz.). Kellerman, 1902, *(O. tenerrima* Kütz.). Lake Erie, Snow, 1902. *(O. tenerrima* Kütz.).

O. subtilissima Kütz. Cincinnati, Twitchell in Kellerman, 1893. Kellerman, 1902. Lake Erie, Snow, 1902.

O. tenuis Ag. Granville, Payne, 1888; Payne in Kellerman, 1893. Cuyahoga Co., Watson, 1900, *(O. natans* Kütz.). Kellerman, 1902. Lake Erie, Snow, 1902, (also as *O. natans* Kütz.); Coyle, 1930. Ohio River drainage streams, Coyle, 1930.

**O. terebriformis* Ag. Near Cincinnati, (Hoskins, Feb. 1927.). Greenhouse, University of Cincinnati, Mar. 1934.

Phormidium Kützing

P. autumnale (Ag.) Gom. Painsville, Beardslee; Delhi, Twitchell in Kellerman, 1893, *(Lyngbya vulgaris* [Kütz.] Kirch.). Kellerman, 1902, *(Lyngbya vulgaris* [Kütz.] Kirchn.).

P. molle Gom. (?) Lake Erie, Coyle, 1930. Alliance, Walton, 1930.

P. Retzii (Ag.) Gom. Alliance, Walton 1930.

Spirulina Turpin

S. Jenneri (Stiz.) Geitl. Lake Erie, Riddle, 1903, *(Arthrospira Jenneri* [Hass.] Stiz.). Big Miami River, North Bend, (Fink, Aug. 1932).

S. major Kütz. Chippewa Lake, Tiffany, 1921. Big Miami River, North Bend, (Fink, Aug. 1932.). Greenhouse, University of Cincinnati, Feb., 1934.

Symploca Kützing

****S. cartilaginea** (Mont.) Gom. Greenhouse, University of Cincinnati, March 1934.

****S. muscorum** (Ag.) Gom. Beaver Pond, Adams Co., (Povah, Oct. 1929).

Nostocaceae

Anabaena Bory

A. circinalis Rabenh. Lake Erie, Vorce, 1881, *(A. gigantea);* Snow, 1902, *(A. Flos-aquae circinalis* [Rabenh.] Kirchn.).

A. Flos-aquae (Lyngbye) Bréb. Lake Erie, Vorce, 1881; Snow, 1902; Coyle, 1930, *(A. Lemmermani* P. Richter). Brush Lake, Champaign Co., Riddle, 1905. Cincinnati, Burnet Woods Lake, (Hoskins, Aug. 1932). Columbus, Mirror Lake, (Runyon, Sept. 1933.).

***A. inaequalis** (Kütz.) Born. and Flah. Addyston, Hamilton Co., Aug. 1933.

A. oscillarioides Bory. Delhi, Twitchell in Kellerman, 1893. Kellerman, 1902.

Aphanizomenon Morren

A. Flos-aquae (L.) Ralfs. Lake Erie, Snow, 1902; Riddle, 1903. *(Asphasrizomenon?).*

Cylindrospermum Kützing

***C. catenatum** Ralfs. Blowville, Clermont Co., Sept., 1933.

***C. majus** Kütz. Addyston, Hamilton Co., Aug., 1933.

***C. muscicola** Kütz. Addyston, Hamilton Co., Aug., 1933.

C. stagnale (Kütz.) Born. & Flah. Delhi, Twitchell, *(Anabaena stagnalis* Kütz. and *C. macrospermum* Kütz.); Columbus, Kellerman in Kellerman, 1893, *(C. macrospermum* Kütz.). Kellerman, 1902, *(C. macrospermum* Kütz., also as *Anabaena stagnalis* Kütz.). Near Cincinnati, (Cooke, Apr. 1933). Addyston, Hamilton Co., Aug. 1933.

Nodularia Mertens

****N. Harveyana** Thuret. Mirror Lake, Columbus, (Runyon, Sept. 1933).

N. paludosa Wolle. Ohio River drainage streams, Coyle, 1930.

N. spumigena Mertens. Brush Lake, Champaign Co., Riddle, 1905. Burnet Woods Lake, Cincinnati, (Hoskins, Aug. 1932). Mirror Lake, Columbus, (Runyon, Sept. 1933).

Nostoc Vaucher

N. caeruleum Lyngbye. Buckeye Lake, Detmers, 1912.

***N. comminutum** Kütz. Near Seven Caves, Highland Co., (Cooke, Aug. 1932). Beaver Pond, Adams Co., Apr. 1933.

N. commune Vauch. Delhi, Twitchell in Kellerman, 1893. Cuyahoga Co., Watson, 1900. Kellerman, 1902, near Seven Caves, Highland Co., (Cooke, Aug. 1932). Beaver Pond, Adams Co., Oct. 1932, and Apr. 1933. Clermont Co., (Braun, March 1933.).

N. cuticulare (Bréb.) Born. and Flah. Buckeye Lake, Detmers, 1912.

N. entophytum Born. and Flah. Cuyahoga Co., Watson, 1900, *(N. tenuissimum)*. Kellerman, 1902, *(N. tenuissimum)*.

N. microscopicum Carm. Granville, Payne, 1888, *(N. rupestre)*; Payne in Kellerman, 1893, *(N. rupestre)*. Kellerman, 1902, *(N. rupestre)*. Near Seven Caves, Highland Co., (Cooke, Aug. 1932). Beaver Pond, Adams Co., Apr. 1933.

N. muscorum Ag. Delhi, Twitchell in Kellerman, 1893. Kellerman, 1902.

**N. paludosum* Kütz. Near Seven Caves, Highland Co., (Cooke, Aug. 1932). Beaver Pond, Adams Co., Apr. 1933.

N. pruniforme Ag. Buckeye Lake, Detmers, 1912.

N. sphaericum Vauch. Delhi, Twitchell in Kellerman 1893. Kellerman, 1902.

Scytonemataceae

Plectonema Thuret

P. Tomasinianum (Kütz.) Born. Lake Erie, Snow, 1902, *(P. mirabile* Thur.).

P. Wollei Farlow. *Delhi,* Twitchell in Kellerman, 1893, *(Lyngbya pallida* [Näg.] Kütz.). Lake Erie, Pieters, 1901, *(L. Wollei)*; Snow, 1902, *(L. Wollei)*. Kellerman, 1902, *(L. pallida* [Näg.] Kütz.).

Scytonema Agardh

S. alatum (Carm.) Borzi. Near Seven Caves, Highland Co., Hoskins, 1933.

**S. mirabile* (Dillw.) Born. Near Seven Caves, Highland Co., (Cooke, Aug. 1932).

**S. myochrous* (Dillw.) Ag. Urbana, (Hoskins, May, 1926). Near Seven Caves, Highland Co., (Cooke, Aug. 1932).

Tolypothrix Kützing

***T. byssoidea* (Hass.) Kirchn. Near Cincinnati, (Hoskins, 1926).

***T. limbata* Thuret. Urbana, (Hoskins, 1926).

***T. Ravenelii* Wolle. Brown Co., (Fulford, Feb. 1933).

***T. Willei* Gardner. Near Seven Caves, (Cooke, Aug. 1932).

Stigonemataceae

Stigonema Agardh

***S. hormoides* (Kütz.) Born. & Flah. Near Seven Caves, Highland Co., (Cooke, Aug. 1932).

***S. minutum* (Ag.) Hass. Near Seven Caves, Highland Co., (Cooke, Aug., 1932).

Rivulariaceae

Calothrix Agardh

C. aeruginea (Kütz.) Thuret. Lake Erie, Snow, 1902, *(Mastigonema aerugineum* Kirchn.).

Gloeotrichia Agardh

G. natans Rabenh. Ross Lake, Twitchell in Kellerman, 1893. Kellerman, 1902. Ohio River drainage streams, Coyle, 1930.

G. Pisum Thuret. Delhi, Twitchell in Kellerman, 1893. Kellerman, 1902.

Rivularia Roth

R. dura Roth. Lake Erie, Snow, 1902, *(R. radicans dura Kirchn.)*.

R. minutula (Kütz.) Born. & Flah. Lake Erie, Snow, 1902, *(R. radicans* Thuret and *R. radicans minutula* Kirchn.).

Rhodophyceae

PROTOFLORIDEAE OF UNCERTAIN POSITION

Porphyridium Nägeli

P. cruentum Näg. Lake Erie, Snow 1902. University of Cincinnati, Greenhouse, 1933.

Florideae

NEMALIONALES

Chantransiaceae

Audouinella Bory

A. violacea (Kütz.) Hamel. Painesville, Beardslee in Kellerman, 1893, *(Chantransia violacea)*. Kellerman, 1902, *(Chantransia violacea)*. Urbana, (Hoskins, 1926).

Batrachospermaceae

Batrachospermum Roth

B. moniliforme Roth. Painesville, Beardslee in Kellerman, 1893. Kellerman, 1902. Hazelwood, Hamilton Co., (Hoskins, 1932, Braun, 1933). [This material will doubtless be found to represent several species.]

Thoreaceae

Thorea Bory

T. ramosissima Bory. Cincinnati, Twitchell in Kellerman, 1893, (also as *Chantransia pygmaea* Kütz.). Lake Erie, Riddle, 1902, (as *Chantransia pygmaea* Kütz.). Kellerman, 1902, (also as *Chantransia pygmaea* Kütz.).

Lemaneaceae

Lemanea Bory

L. borealis Atkinson. Painesville, Atkinson, 1892; *(L. fucina* var. *rigida* Atkins.); Muencher, 1931 [same material].

L. fucina Bory. Painesville, Wolle, 1879, *(Chantransia Beardsleei* Wolle ?, not possible to trace synonym); Beardslee in Kellerman, 1893, *(Chantransia violacea Beardsleei* Wolle). Kellerman, 1902.

L. torulosa (Roth) Ag. Painesville, Beardslee in Kellerman, 1893. Kellerman. 1902.

FLORIDEAE OF UNCERTAIN POSITION.

Hildenbrandia Nardo

***H. rivularis* (Liebm.) J. Ag. Hamilton Co. (Bucher, 1932).

Heterokontae

HETEROCOCCALES

Halosphaeraceae

Botrydiopsis Borzi

B. eriensis Snow. Lake Erie, Snow, 1902.

Botryococcaceae

Botryococcus Kützing

B. Braunii Kütz. Lake Erie, Snow, 1902. Brush Lake, Champaign Co., Riddle, 1905.

Chlorobotrys Bohlin

C. neglecta Pasch. & Geitl. Mansfield, Walton, 1930.

Ophiocytaceae

Ohpiocytium Nägeli

O. capitatum Wolle. Lake Erie, Snow, 1902.

O. parvulum (Perty). A. Br. Lake Erie, Snow, 1902.

HETEROTRICHALES

Tribonemataceae

Tribonema Derbishire & Solier [2]

T. bombycinum (Ag.) Derb. & Sol. Granville, Herrick in Kellerman, 1893. Kellerman, 1902. Buckeye Lake, Tiffany, 1921. Goshen, (Hoskins, 1926). Lake Erie, Coyle, 1930. Swing Fill, Mt. Airy Forest, Cincinnati, (Cooke, 1933). Madeira, 1933. Blowville, Clermont Co., Apr. 1934. var. *tenue* Hazen. Buckeye Lake, Tiffany, 1921. Hamilton Co. (Cooke, 1934).

**T. minus* West. Madeira, 1933.

HETEROSIPHONALES

Botrydiaceae

Botrydium Wallroth

B granulatum (L.) Grev. Cincinnati, Twitchell in Kellerman, 1893. Kellerman, 1902. Addyston, (Hoskins, 1933).

Chrysophyceae

CHRYSOMONADALES

Synuraceae

Synura Ehrenberg

S. Volvox Ehrenb. Lake Erie, Snow, 1902.

Ochromonadaceae

Dinobryon Ehrenberg

D. Sertularia Ehrenb. Lake Erie, Vorce, 1881.

Chlorophyceae

VOLVOCALES

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2 The species of Conferva L. have been distributed among various genera by a number of algologists. The following species, however, we have been unable to trace further than DeToni (1889).

C. glacialoides Wolle. Painesville, Beardslee in Kellerman, 1893, Kellerman 1902.

C. rhypophila Kütz. Granville, Payne, 1888; Payne in Kellerman, 1893. Kellerman 1902.

C. tenerrima rhypophila. Kellerman 1902. (Probably *Tribonema tenerrimum* Heering).

Chlamydomonadaceae
Chlamydomonas Ehrenberg

C. sp. Lake Erie, Vorce, 1881. *(Monas lens).*
C. globosa Snow. Lake Erie, Snow, 1902.
C. gracilis Korshik. Lake Erie, Snow, 1902.
C. Snowiae Printz. Lake Erie, Snow, 1902, *(C. communis* Snow).

Volvocaceae
Eudorina Ehrenberg

E. elegans Ehrenb. Lake Erie, Snow, 1902; Riddle, 1903. Chippewa Lake, Tiffany, 1921. Lake Erie, Coyle, 1930.
E. illinoisensis (Kofoid) Pascher. Buckeye Lake, Tiffany, 1921, *(Pleodorina illinoisensis* Kofoid).

Gonium Müller

G. pectorale Müller. Lake Erie, Snow, 1902. Chippewa Lake, Tiffany, 1921.

Pandorina Bory

P. Morum (Müll.) Bory. Delhi, Twitchell in Kellerman, 1893. Lake Erie, Snow, 1902; Riddle, 1903. Kellerman, 1902. Brush Lake, Riddle, 1905. Buckeye Lake, Chippewa Lake, Tiffany, 1921.

Volvox Linnaeus

V. aureus Ehrenb. Buckeye Lake, Tiffany, 1921.
V. Globator (L.) Ehrenb. Delhi, Twitchell in Kellerman, 1893. Lake Erie, Snow, 1902; Riddle, 1903. Kellerman, 1902.

Spondylomoraceae
Spondylomorum Ehrenberg

S. quaternarium Ehrenb. Lake Erie, Riddle, 1903. Brush Lake, Riddle, 1905.

Sphaerellaceae
Sphaerellopsis Korshikov

S. fluviatilis (Stein) Pascher. Cincinnati, Twitchell in Kellerman, 1893. *(Chlamydococcus fluvialis* A. Br.).

Stephanoon Schewiakoff

S. Wallichii Wille. Buckeye Lake, Chippewa Lake, Tiffany, 1921, *(Eudorinella Wallichii* [Turp.] Lemm.).

TETRASPORALES
Palmellaceae
Gloeocystis Nägeli

G. gigas (Kütz.) Lagerh. Lake Erie, Vorce, 1881, *(Gloeocapsa ampla* Kütz.); Snow, 1902, *(G. ampla* Kütz.); Riddle, 1903. Columbus, Kellerman, 1893, *(G. ampla* Kütz.). Buckeye Lake, Tiffany, 1921.

Palmella Lyngbye

***P. minata* Leiblein. Blowville, Clermont Co., Apr. 1934.

Sphaerocystis Chodat

S. Schroeteri Chod. Mirror Lake, Columbus, Walton, 1918, (*Eutetramorus globosus* Walton). Ohio River drainage streams, Coyle, 1930.

Tetrasporaceae

Schizochlamys A. Braun

S. gelatinosa A. Br. Lake Erie, Snow, 1902.

Tetraspora Link

T. bullosa (Roth) Ag. Delhi, Twitchell in Kellerman, 1893. Kellerman, 1902.
T. explanata (Kütz.) Kirchn. Delhi, Twitchell in Kellerman, 1893. Kellerman, 1902.
**T. gelatinosa* (Vauch.) Desvaux. Newtown, Hamilton Co., Apr. and Oct., 1933. Quinn School, Brown Co., Apr. 1934.
T. lubrica (Roth) Ag. Columbus, Mrs. Kellerman and Bogue in Kellerman, 1893. Kellerman, 1902. Adams Co., March 1933. Madeira, Apr., 1933.
T. natans Kütz. Lake Erie, Snow, 1902.

Coccomyxaceae

Chlorosarcina Gerneck

C. lacustris (Snow) Lemm. Lake Erie, Snow, 1902, (*Chlorosphaera lacustris* Snow).
C. parvula (Snow) Lemm. Lake Erie, Snow, 1902, (*Chlorosphaera lacustris* var. *parvula* Snow).

Elakatothrix Wille

E. viridis (Snow) Printz. Lake Erie, Snow, 1902, (*Fulosa viridis* Snow.).

ULOTRICHALES

Ulotrichaceae

Geminella Turpin

G. minor (Näg.) Heer. Ohio River drainage streams, Coyle, 1930.
**G. ordinata* (W. & G. S. West) Heer. Adams Co., April, 1933.

Hormidium Kützing

H. flaccidum (Kütz.) A. Br. Painesville, Beardslee in Kellerman, 1893, (*Ulothrix flaccida* Kütz.). Cuyahoga Co., Watson, 1900, (*U. flaccida* Kütz.).

Radiofilum Schmidle

***R. flavescens* G. S. West. West Fork of Mill Creek, April, 1933.

Stichococcus Nägeli

S. bacillaris Näg. Lake Erie, Snow, 1902.

Ulothrix Kützing

**U. aequalis* Kütz. Madeira, West Fork of Mill Creek, April, 1933.
U. oscillarina Kütz. St. Mary's Lake, Tiffany, 1921. Muddy Creek, Hamilton Co., 1934.

U. subtilis Kütz. Cincinnati, Twitchell in Kellerman, 1893.
var. *variabilis* (Kütz.) Kirchn. Columbus, Eldridge in Kellerman, 1893.
U. tenerrima Kütz. Lake Erie, Coyle, 1930. Adams Co., 1934. Muddy Creek, Hamilton Co., 1934.
U. zonata (Web. & Mohr) Kütz. Cincinnati, Twitchell in Kellerman, 1893. Columbus, Kellerman, 1893. Cuyahoga Co., Watson, 1900.

Microsporaceae

Microspora Thuret

M. floccosa (Vauch.) Thur. Cuyahoga Co. Watson, 1900. (*Conferva floccosa* Ag.). Kellerman, 1902.
M. fontinalis (Berk.) DeToni. Kellerman, 1902.
M. fugacissima (Roth) Rabenh. Lake Erie, Riddle, 1903.
**M. pachyderma* (Wille) Lagerh. Adams Co., 1932.
**M. stagnorum* (Kütz.) Lagerh. Clermont Co., 1933. Muddy Creek, Hamilton Co., 1934.
M. vulgaris Rabenh. Painesville, Beardslee in Kellerman, 1893. (also as *Conferva vulgaris Farlowii* Wolle). Columbus, Bogue in Kellerman, 1893. Cuyahoga Co., Watson, 1900, (also as *Conferva Farlowii* Wolle). Kellerman, 1902. Castalia, Riddle, 1903.

Cylindrocapsaceae

Cylindrocapsa Reinsch

C. amoena Wolle. Muddy Creek, Twitchell in Kellerman, 1893. Kellerman, 1902.
C. geminella Wolle. Tiffany, 1924 (2).
var. *minor* Tiffany. Tiffany 1924 (2).

Chaetophoraceae

Aphanochaete A. Braun

A. repens A. Br. Columbus, Kellerman, 1893. Lake Erie, Snow, 1902. Kellerman, 1902.

Chaetophora Schrank

C. elegans (Roth) Ag. Delhi, Twitchell in Kellerman, 1893. Kellerman, 1902. Adams Co., (Hoskins 1929).
C. incrassata (Huds.) Hazen. Painesville, Beardslee in Kellerman, 1893. (*C. endiviaefolia* Ag.). Delhi, Twitchell in Kellerman, 1893. (*C. endiviaefolia* Ag.). Columbus, Kellerman, 1893. (*C. endiviaefolia linearis* Rabenh.). Kellerman 1902, (*C. Cornu-Damae* [Roth] Ag.). Lake Erie, Snow, 1902, (*C. endiviaefolia* Ag.). Symmes, Hamilton Co., (Cooke, 1933). Twin Bridges, Clermont Co., 1933.
C. pisiformis (Roth) Ag. Granville, Payne, 1888. Columbus, Kellerman, 1893. Delhi, Twitchell in Kellerman, 1893. Kellerman, 1902.

Draparnaldia Bory

**D. acuta* (Ag.) Kütz. Quinn School, Brown, Co., (Fulford, 1934).

D. glomerata (Vauch.) Ag. Painesville, Beardslee in Kellerman, 1893. Delhi, Twtichell; Columbus, Kellerman; Ironton, Werner (all) in Kellerman, 1893. Cuyahoga Co., Watson, 1900. Kellerman, 1902 *(Drapernaudia)*. Madeira, (Baur, 1933). Clermont Co.; Adams Co., 1933 and 1934.
var. *maxima* Wood. Cuyahoga Co., Watson, 1900. Kellerman, 1902.
**D. platyzonata* Hazen. Near Newton, Hamilton Co., (Braun, 1934).
D. plumosa (Vauch.) Ag. Delhi, Twitchell in Kellerman, 1893. Kellerman, 1902.
D. Ravenelli Wolle. Columbus, Kellerman, 1893. Kellerman, 1902, *(Drapernaudia)*.

Microthamnion Nägeli

***M. strictissimum* Rabenh. Lake Isabella, Hamilton Co., 1933.

Stigeoclonium Kützing

S. nanum (Dillw.) Kütz. Cincinnati, Twitchell in Kellerman, 1893. Kellerman 1902.
S. radians Kütz. Cincinnati, Twitchell in Kellerman, 1893. Kellerman, 1902.
**S. stagnatile* Hazen. Cincinnati, 1934. Muddy Creek, Hamilton Co., 1934.
S. tenue (Ag.) Rabenh. Cincinnati, Twitchell, 1885. Twitchell in Kellerman, 1893. Lake Erie, Snow, 1902. Ohio River drainage streams, Coyle, 1930. Newton Pike, Hamilton Co., 1933.
var. *genuinum* (Kütz.) Kirchn. Kellerman, 1902.

Protococcaceae
Protococcus Agardh

P. aquaticus Snow. Lake Erie, Snow, 1902. *(Pleurococcus aquaticus* Snow).
P. regularis Artari. Lake Erie, Snow, 1902. *(Pleurococcus regularis* Arta.).
P. viridis Ag. Cincinnati, Twitchell in Kellerman, 1893. Cincinnati, 1934.
var. *gigas* Fairfield Co., Kellerman, 1893. Kellerman, 1902.

Coleochaetaceae
Coleochaete Brébisson

C. scutata Bréb. Delhi, Twitchell in Kellerman, 1893. Lake Erie, Snow, 1902. Kellerman, 1902.
C. soluta (Bréb.) Pringsh. Delhi, Twitchell in Kellerman, 1893. Kellerman, 1902.

Trentepohliaceae
Trentepohlia Martius

***T. aurea* (L.) Martius. Adams Co., 1933.

Cladophoraceae
Cladophora Kützing

**C. callicoma* Kütz. Burnet Woods Lake; Montgomery Creek, Hamilton Co.; Adams Co., 1933.
C. crispata (Roth) Kütz. Cincinnati, Twitchell; Granville, Herrick in Kellerman, 1893. Kellerman, 1902. Ohio River drainage streams, Coyle, 1930.
var. *vitrea* (Kütz.) Rabenh. Cuyahoga Co., Watson. 1900. Kellerman, 1902.

C. declinata Kütz. var. *fluitans* (Kutz.) Hansg. Castalia, Riddle, 1903. Brush Lake, Riddle, 1905.
C. fontanemus Mirror Lake, Columbus, Kraatz, 1921.
C. fracta (Dillw.) Kütz. Painesville, Beardslee; Cincinnati, Twitchell in Kellerman, 1893. Cuyahoga Co., Watson, 1900. Kellerman, 1902.
C. glomerata (L.) Kütz. Painesville, Beardslee; Cincinnati, Twitchell; Georgeville, Bogue, (all) in Kellerman, 1893. Hatchery Bay, Pieters, 1901. Kellerman, 1902. Ohio River drainage streams, Coyle, 1930. Nine Mile Road and Twin Bridges, Clermont Co., 1933. Clermont Co., (Braun, 1933).
var. *clavata* Wolle. Cuyahoga Co., Watson, 1900.
†var. *pumila* Bail. Cuyahoga Co., Watson, 1900. Kellerman, 1902.
var. *rivularis* Rabenh. Cuyahoga Co., Watson, 1900. Kellerman, 1902.
†var. *subsimplex* Rabenh. Lake Erie, Snow, 1902.
C. holsatica Kütz. Cincinnati, Twitchell in Kellerman, 1893, *(C. aegagropila* [L.] Kütz.)
**C. Keutzingiana* Grunau. Addyston; University of Cincinnati campus, 1934.
C. Linnaei Kütz. Kellerman, 1902.
**C. uberrima* Lambert. Adams Co., 1933.

Hormiscia Hansgirg

H. flaccida (Kütz.) Lagerh. Kellerman, 1902. Lake Erie, Snow, 1902. *(Hormidium nitens flaccidum* [Kütz] A. Br.)
H. subtilis (Kütz.) DeToni. Kellerman, 1902.
var. *variabilis* (Kütz.) Kirchn. Kellerman, 1902.

Pithophora Wittrock

P. Oedogonia (Mont.) Wittr. Kellerman, 1902.
**P. varia* Wille. Hamilton Co., 1933.

Rhizoclonium Kützing

R. hieroglyphicum (Ag.) Kütz. Ohio River drainage streams, Coyle, 1930. Hamilton Co., 1933.

OEDOGONIALES

Oedogoniaceae.

Bulbochaete Agardh

B. basispora Wittr. & Lundell. Tiffany, 1930.
B. crassa Pringsheim. Tiffany, 1930.
B. crenulata Pringsh. Muddy Creek, Delhi, Twitchell in Kellerman, 1893. Kellerman, 1902.
B. intermedia DeBary. Tiffany, 1930.
B. Nordstedtii Wittr. Tiffany, 1930.
B. quadrata Wittr. Tiffany, 1930.
B. rectangularis Wittr. Tiffany, 1930.
B. rhadinospora Wittr. Lake Erie, Riddle, 1903

B. varians Wittr. Tiffany, 1930.
var. *hawaiensis* Nordst. Tiffany, 1930.
var.*subsimplex* (Wittr.) Hirn. Tiffany, 1930.

Oedogonium Link

O. acrosporum DeBary. Tiffany, 1930.
O. areolatum Lagerh. Tiffany, 1930.
O. Boscii (LeCl.) Wittr. Tiffany, 1930.
O. capillare (L.) Kütz. Painesville, Beardslee in Kellerman, 1893. Cuyahoga Co., Watson, 1900. Kellerman, 1902.
O. capilliforme (Kütz.) Wittr. Cuyahoga Co., Watson, 1900. Kellerman, 1902. Tiffany, 1930.
O. capitellatum Wittr. Tiffany, 1930.
O. cardiacum (Hass.) Wittr. Cuyahoga Co., Watson, 1900. Kellerman, 1902. Tiffany, 1930.
var. *carbonicum* Wittr. Tiffany, 1930.
O. ciliatum (Hass.) Pringsh. Tiffany, 1930.
O. crassiusculum Wittr. var. *cataractum* (Wolle) Tiffany. Tiffany 1930.
var. *idioandrosporum* Nordst. & Wittr. Loramie Lake, Tiffany, 1921. Tiffany, 1930.
O. crassum (Hass.) Wittr. Tiffany, 1930.
var. *amplum* (Magnus & Wille) Hirn. Tiffany, 1930.
O. crenulatocostatum Wittr. Tiffany, 1930.
O. crispum (Hass.) Wittr. Delhi, Twitchell in Kellerman, 1893. Kellerman, 1902. Tiffany, 1930.
var. *gracilescens* Wittr. Tiffany, 1930.
O. cryptoporum Wittr. Delhi, Twitchell in Kellerman, 1893. Lake Erie, Snow, 1902. Kellerman, 1902.
O. cyathigerum Wittr. Tiffany, 1930.
var. *ellipticum* Magnus & Wille. Tiffany, 1930.
var. *perfectum* Hirn. Tiffany, 1930.
O. echinospermum A. Br. Tiffany, 1930.
O. exocastatum Tiffany. Akron, Tiffany, 1921, and 1930.
O. exospirale Tiffany. Ohio River drainage streams, Coyle, 1930. Tiffany, 1930.
O. flavescens (Hass.) Wittr. Tiffany, 1930.
O. fonticola A. Br. Painesville, Beardslee in Kellerman, 1893. Kellerman, 1902.
O. fragile Wittr. Granville, Payne in 1888. Payne in Kellerman, 1893. Kellerman, 1902.
O. giganteum Kütz. Tiffany, 1930.
O. gracillimum Wittr. & Lund. Cincinnati, Twitchell in Kellerman, 1893. Kellerman, 1902. Tiffany, 1930.
O. grande Kütz. Wittr. Tiffany, 1930.
var. *majus* Hansg. Tiffany, 1930.
O. intermedium Wittr. Tiffany, 1930.

O. iowense Tiffany. Tiffany, 1930.
O. irregulare Wittr. Tiffany, 1930.
O. Landsboroughi (Hass.) Wittr. Tiffany, 1930.
O. macrandrium Wittr. Tiffany, 1930.
var. *Hohenackerii* (Wittr.) Tiffany. Tiffany, 1930.
O. moniliforme Wittr. Tiffany, 1930.
O. obtruncatum Wittr. Tiffany, 1930.
O. paludosum (Hass.) Wittr. Cuyahoga Co., Watson, 1900. Kellerman, 1902.
var. *parvisporum* Hirn. Tiffany, 1930.
O. paucocostatum Transeau. Tiffany, 1930.
var. *gracilis* Tiffany. Akron, Tiffany, 1921, 1930.
O. pisanum Wittr. Tiffany, 1930.
O. plagiostomum Wittr. Tiffany, 1930.
var. *gracilius* Wittr. Tiffany, 1930.
O. pratense Transeau. Tiffany, 1930.
O. praticolum Transeau. Tiffany, 1930.
O. Pringsheimii Cramer. Tiffany, 1930.
var. *Nordstedtii* Wittr. Tiffany, 1930.
O. rufescens Wittr. Tiffany, 1930.
O. Sancti-Thomae Wittr. & Cleve. Tiffany, 1930, ("Imperfectly known").
O. spurium Hirn. Tiffany, 1930, ("Imperfectly known").
O. taphrosporum Nordst. & Hirn. Tiffany, 1921.
O. upsaliense Wittr. Tiffany, 1930.
O. varians Wittr. & Lund. Granville, Payne, 1888; Payne in Kellerman, 1893. (*O. polymorphum* Wittr. & Lund.). Kellerman, 1902 (*O. polymorphum* Wittr. & Lund.).
O. Vaucherii (LeCl). A. Br. Tiffany, 1930.
O. wabashense Tiffany. Tiffany, 1930.
O. Wolleanum Wittr. Painesville, Beardslee in Kellerman, 1893. Kellerman, 1902.

CHLOROCOCCALES

Chlorococcaceae

Chlorococcum Fries

C. endozoicum Collins. Lake Erie, Snow, 1902, (*C. natans* Snow).
C. infusionum (Schrank) Menegh. Lake Erie, Snow, 1902, (also as *Chlorella infusionum* Beyerink).

Golenkinia Chodat

G. maxima Tiffany & Ahlstrom. Lake Erie, Tiffany and Ahlstrom, 1931.
G. radiata Chodat. var. *brevispine* Tiffany & Ahlstrom. Lake Erie, Tiffany and *Ahlstrom*, 1931.

Endosphaeraceae

Chlorochytrium Cohn

C. Lemnae Cohn. Buckeye Lake, Detmers, 1912.

Kentrosphaera Borzi

K. Bristolae Smith. Lake Erie, Snow, 1902. (*Scotinosphaera paradoxa* Klebs).

Characiaceae

Characium A. Braun

C. ambiguum Hermann. Lake Erie, Snow, 1902.

C. angustatum A. Br. Lake Erie, Snow, 1902.

C. sessile Hermann. Cincinnati, Twitchell in Kellerman, 1893. Kellerman, 1902.

Richteriella Lemmerman

R. botryoides (Schmidle) Lemm. Lake Erie, Snow, 1902. *(Golenkinia fenestrata* Schrod.).

Protosiphonaceae

Protosiphon Klebs.

P. botryoides (Kütz.) Klebs. Lake Erie, Snow, 1902. Addyston, (Hoskins, 1932).

Hydrodictyaceae

Hydrodictyon Roth

H. reticulatum (L.) Lagerh. Painesville, Beardslee, 1875. Beardslee in Kellerman, 1893. Cincinnati, Twitchell; Granville, Eldridge; Columbus, Werner; all in Kellerman, 1893, *(H. utriculatum* Roth). Lake Erie, Snow, 1902; Riddle, 1903. Kellerman, 1902. Hamilton Co., (Cooke, 1933).

Pediastrum Meyen

P. angulosum (Ehrenb.) Menegh. Granville, Jones, 1887. Jones in Kellerman, 1893. Kellerman, 1902.

P. biradiatum Meyen. Lake Erie, Snow, *(P. rotula* A. Br.), 1902. Buckeye Lake, Akron, Tiffany, 1921.

var. *emarginatum* A. Br. Akron, Tiffany, 1921.

P. Boryanum (Turp.) Menegh. Lake Erie, Vorce, 1881. Granville, Jones, 1887. Jones in Kellerman, 1893. Delhi, Twitchell in Kellerman, 1893. Kellerman, 1902. Lake Erie, Snow, 1902; Riddle, 1903; Coyle, 1930. Brush Lake, Riddle, 1905. Buckeye Lake, Indian Lake, St. Mary's Lake, Chippewa Lake, Loramie Lake, Akron, Tiffany, 1921, Hamilton, Walton, 1930. Ohio River drainage streams, Coyle, 1930.

var. *brevicorne* A. Br. Buckeye Lake, Tiffany, 1921.

var. *forcipatum* Racib. Buckeye Lake, Tiffany, 1921.

var. *granulatum* (Kütz.) A. Br. Lake Erie, Vorce, 1881. Buckeye Lake, Tiffany, 1921.

var. *longicorne* Reinsch. Lake Erie, Snow, 1902. Buckeye Lake, Tiffany, 1921.

var. *perforatum* Racib. Buckeye Lake, Tiffany, 1921.

P. clathratum (Schr.) Lemm. Buckeye Lake, Indiana Lake, St. Mary's Lake, Akron, Tiffany, 1921.

var. *duodenarium* Bailey. Buckeye Lake, Akron, Tiffany, 1921.

var. *microsporum* Lemm. Buckeye Lake, Tiffany, 1921. Ohio River drainage streams, Coyle, 1930.

var. *punctatum* Lemm. Buckeye Lake, Tiffany, 1921.

P. constrictum Hass. Lake Erie, Snow, 1902.

P. duplex Meyen. Lake Erie, 1902, (*P. pertusum* Kütz.); Riddle, 1903; Coyle, 1930. Buckeye Lake, Indian Lake, Loramie Lake, St. Mary's Lake, Chippewa Lake, Akron, Tiffany, 1921.

var. *brachylobum* A. Br. Lake Erie, Snow, 1902. (*P. pertusum brachylobum* A. Br.).

var. *clathratum* A. Br. Lake Erie, Snow, 1902; Coyle, 1930.

var. *microsporum* A. Br. Lake Erie, Snow, 1902.

var. *reticulatum* Lagerh. Buckeye Lake, Indian Lake, Akron, Tiffany, 1921.

var. *subgranulatum* Racib. Buckeye Lake, Tiffany, 1921.

P. integrum Nägeli. South Charleston, Walton, 1930.

P. simplex (Meyen) Lemm. Granville, Jones 1887; Jones in Kellerman, 1893. Kellerman, 1902. Buckeye Lake, Indian Lake, Loramie Lake, St. Mary's Lake, Chippewa Lake, Akron, Tiffany, 1921. Xenia, Walton, 1930. Ohio River drainage streams, Coyle, 1930.

var. *ovatum* (Ehrenb.) Tiffany. Lake Erie, Snow, 1902, (*P. Sturmii* Reinsch).

var. *radians* Lemm. Buckeye Lake, St. Mary's Lake, Akron, Tiffany, 1921.

P. Tetras (Ehrenb.) Ralfs. Granville, Jones, 1887. Jones in Kellerman, 1893. Lake Erie, Snow, 1902, (all three as *P. Ehrenbergii* A. Br.); Riddle, 1903. Twitchell in Kellerman, 1893. Kellerman, 1902. Brush Lake, Riddle, 1905. Buckeye Lake, St. Mary's Lake, Akron, Tiffany, 1921.

var. *excisum* Rabenh. St. Mary's Lake, Akron, Tiffany, 1921.

Sorastrum Kützing

S. spinulosum Näg. Lake Erie, Snow, 1902; Riddle, 1903.

Coelastraceae

Coelastrum Nägeli

C. cambricum Archer. Lake Erie, Riddle, 1903. Brush Lake, Riddle, 1905.

C. microsporum Näg. Lake Erie, Snow, 1902; Riddle, 1903; Coyle 1930. Brush Lake, Riddle, 1905. Buckeye Lake, Indian Lake, Loramie Lake, St. Mary's Lake, Chippewa Lake, Akron, Tiffany, 1921.

C. Morus W. & G. S. West var. *capense* Fritsch. Akron, Tiffany, 1921.

C. proboscideum Bohlin. Lake Erie, Snow, 1902.

C. reticulatum (Dang.) Senn. Lake Erie, Snow, 1902. Akron, Tiffany, 1921.

C. sphaericum Näg. Lake Erie, Snow, 1902. Buckeye Lake, Indian Lake, St. Mary's Lake, Akron, Tiffany, 1921.

Oöcystaceae

Ankistrodesmus Corda

A. biplex Reinsch. Lake Erie, Snow, 1902. (*Raphidium biplex* Reinsch).

A. Braunii Näg. Lake Erie, Snow, 1902, (*Raphidium Braunii* Näg.).

A. convolutus Corda. Lake Erie, Snow, 1902; Riddle, 1903; Brush Lake, Riddle, 1905. (All as *Raphidium convolutum* [Corda] Rabenh.).

A. falcatus (Corda) Ralfs. Delhi, Twitchell in Kellerman, 1893, *(Raphidium polymorphum* Fres.). Lake Erie, Snow, 1902, *(Raphidium falcula* A. Br. and *R. polymorphum* Fres.); Riddle, 1903, *(Raphidium falcatum* [Corda] Rabenh. and *R. polymorphum* Fres.); Coyle, 1930. St. Mary's Lake, Tiffany, 1921. Springfield, Walton, 1930. Ohio River drainage streams, Coyle, 1930.

var. *acicularis* A. Br. Lake Erie, Vorce, 1881. *(Closterium Griffithsii* Berk.); Riddle 1903, *(Raphidium aciculare* [A. Br.] Rabenh.). Brush Lake, Riddle, 1905. *(Raphidium aciculare* [A. Br.] Rabenh.).

var. *mirabilis* W. & G. S. West. Indian Lake, Tiffany, 1921.

A. setigerus (Schröder) G. S. West var. *minor* (Schröder) G. S. West. Ohio River drainage streams, Coyle, 1930.

A. spiralis (Turner) Lemm. Lake Erie, Snow, 1902, *(Raphidium spirale* Turner).

Chlorella Beyerinck

C. ellipsoidea Gerneck. Springfield, Walton, 1930.

C. pachyderma Printz. Buckeye Lake, Chippewa Lake, Tiffany, 1921.

C. vulgaris Beyerinck. Lake Erie, Snow, 1902.

Dactylococcus Nägeli

D. infusionum Näg. Lake Erie, Snow, 1902.

Dictyosphaerium Nägeli

D. Ehrenbergianum Näg. Lake Erie, Snow, 1902; Coyle, 1930.

D. planctonicum Tiffany & Ahlstrom. Lake Erie, Tiffany and Ahlstrom, 1931.

D. pulchellum Wood. Lake Erie, Snow, 1902; Coyle, 1930.

Dimorphococcus A. Braun

D. cordatus Wolle. Lake Erie, Riddle, 1903.

D. lunatus A. Br. Lake Erie, Snow, 1902.

Franceia Lemmermann

F. ovalis (Francé) Lemm. St. Mary's Lake, Tiffany, 1921.

F. tuberculata G. M. Smith. Lake Erie, Tiffany and Ahlstrom, 1931.

var. *irregularis* Tiffany & Ahlstrom. Lake Erie, Tiffany and Ahlstrom, 1931.

Kirchneriella Schmidle

K. contorta (Schmidle) Bohlin. Lake Erie, Snow, 1902, *(K. obesa contorta* Schmidle).

K. lunaris (Kirchn.) Möb. Lake Erie, Snow, 1902. St. Mary's Lake, Chippewa Lake, Akron, Tiffany, 1921.

var. *Dianae* Bohlin. Lake Erie, Snow, 1902.

K. obesa (W. West) Schmidle. Lake Erie, Snow, 1902; Coyle 1930. Buckeye Lake, Loramie Lake, St. Mary's Lake, Chippewa Lake, Tiffany, 1921.

var. *major* (Ber.) G. M. Smith. Buckeye Lake, Indian Lake, Loramie Lake, Tiffany, 1921.

K. subsolitaria G. S. West. St. Mary's Lake, Tiffany, 1921.

Lagerheimia Chodat

L. ciliata (Lagerh.) Chod. var. *amphitrichia* (Lagerh.) Chod. Buckeye Lake, Indian Lake, Chippewa Lake, Tiffany, 1921.

L. citriformis (Snow) Smith. Lake Erie, Snow, 1902 *(Chodatella citriformis* Snow); Walton, 1930; Tiffany and Ahlstrom, 1931. St. Mary's Lake, Chippewa Lake, Tiffany, 1921.

var. *paucispina* Tiffany & Ahlstrom. Lake Erie, Tiffany and Ahlstrom, 1931.

L. genevensis Chod. var. *subglobosa* (Lemm.) Chod. Buckeye Lake, Tiffany, 1921.

L. longiseta (Lemm.) Printz var. *major* G. M. Smith. Lake Erie, Tiffany and Ahlstrom. 1931.

L. longispina Walton. Columbus, Walton, 1930.

L. wratislawiensis Schröder. Lake Erie, Tiffany and Ahlstrom, 1931.

Nephrocytium Nägeli

N. Agardhianum Näg. Lake Erie, Snow, 1902.

Oöcystis Nägeli

O. Borgei Snow. Lake Erie, Snow, 1902; Coyle, 1930. Buckeye Lake; Indian Lake; St. Mary's Lake; New Reservoir, Akron, Tiffany, 1921.

O. elliptica W. West. St. Mary's Lake, Tiffany, 1921.

forma *minor* W. West. Ohio River drainage streams, Coyle, 1930.

O. eremosphaeria G. M. Smith. Lake Erie, Tiffany and Ahlstrom, 1931.

O. pusilla Hansg. St. Mary's Lake, Tiffany, 1921.

O. lacustris Chodat. Lake Erie, Snow, 1902.

O. [illegible]ria Witt[illegible]. Lake Erie, Snow, 1902.

Schroederia Lemmermann

S. Juday[illegible] G. M. Smith. Lake Erie, Coyle, 1930.

Selenastrum Reinsch

S. Bibraianum Reinsch. Lake Erie, Snow, 1902.

var. *gracile* (Reinsch) Tiffany & Ahlstrom. Lake Erie, Tiffany, and Ahlstrom, 1931.

S. gracile Reinsch. Lake Erie, Snow, 1902. New Reservoir, Akron, Tiffany, 1921.

S. minutum (Näg.) Coll. Lake Erie, Snow, 1902. *(Raphidium minutum* Näg.).

Treubaria Bernard

T. varia Tiffany & Ahlstrom. Lake Erie, Tiffany and Ahlstrom, 1931.

Tetraëdron Kützing

T. sp. Lake Erie, Snow, 1902. *(Polyedrium cruentum* Näg.).

T. enorme (Ralfs) Hansg. Lake Erie, Snow, 1902, *(Polyedrium enorme* De-Bary); Riddle, 1903. Brush Lake, Champaign Co., Riddle, 1905. Buckeye Lake, Tiffany, 1921.

var. *aequisectum* Reinsch. Buckeye Lake, Tiffany, 1921.

T. gigas (Wittr.) Hansg. Lake Erie, Snow, 1902. *(Polyedrium gigas* Wittr.).

T. hastatum (Rabenh.) Hansg. var. *palatinum* (Schm.) Lemm. Buckeye Lake, St. Mary's Lake, Tiffany, 1921.
T. lobulatum (Näg.) Hansg. Lake Erie, Snow, 1902. *(Polyedrium lobulatum* Näg.).
T. minimum (A. Br.) Hansg. Lake Erie, Snow, 1902, *(Polyedrium pinacidium* Reinsch, and *P. minimum* A. Br.); Riddle, 1903; Coyle, 1930. Buckeye Lake, Tiffany, 1921.
T. muticum (A. Br.) Hansg. Buckeye Lake; Indian Lake; Loramie Lake; St. Mary's Lake; Chippewa Lake; New Reservoir, Akron, Tiffany, 1921. Lake Erie, Snow, 1902. *(Polyedrium muticum* A. Br.).
T. regulare Kütz. Buckeye Lake, Tiffany, 1921.
var. *longispinum* Reinsch. Buckeye Lake, Tiffany, 1921.
var. *torsum* Turn. Buckeye Lake, Chippewa Lake, Tiffany, 1921.
T. trigonum Näg. Lake Erie, Snow, 1902 *(Polyedrium trigonum* Näg., and *P. tetragonum* Rabenh.); Riddle, 1903, *(P. tetragonum* Rabenh.)
var. *bifurcatum* Wolle. Lake Erie, Riddle 1903. (Considered questionable by DeToni.)
var. *gracile* Reinsch. Buckeye Lake; Loramie Lake, New Reservoir, Akron, Tiffany, 1921.
var. *minus* Reinsch. Lake Erie, Riddle, 1903.
T. tropicum W. & G. S. West. Ohio River drainage streams, Coyle, 1930.

Westella de Wildemann

W. botryoides (W. West) de Wildemann. Lake Erie, Coyle, 1930.

Scenedesmaceae

Actinastrum Lagerheim

A. gracillimum G. M. Smith. Lake Erie, Coyle, 1930.
A. Hantzschii Lag. St. Mary's Lake, Tiffany, 1921.

Crucigenia Morren

+C. sp. Lake Erie, Riddle, 1903, *(Staurogenia cruciata* Wolle).
C. apiculata (Lemm.) Schmidle. Lake Erie, Snow, *(S. apiculata* Lemm.), 1902.
var. *eriensis* Tiffany & Ahlstrom. Lake Erie, Tiffany and Ahlstrom, 1931.
C. emarginata (W. & G. S. West) Schm. Buckeye Lake, Tiffany, 1921.
C. irregularis Wille. Loramie Lake; New Reservoir, Akron, Tiffany 1921.
C. quadrata Morren. Lake Erie, Snow, 1902, *(Staurogenia quadrata* [Morren] Kütz.) Buckeye Lake, Tiffany, 1921.
C. rectangularis (A. Br.) Gay. Lake Erie, Snow, 1902, *(Staurogenia rectangularis* [Näg.] A. Br.). Indian Lake, Buckeye Lake; Loramie Lake; New Reservoir, Akron, Tiffany, 1921.
C. Tetrapedia (Kirchn.) W. & G. S. West. Buckeye Lake; Loramie Lake; Chippewa Lake; New Reservoir, Akron, Tiffany, 1921.

Micractinium Fresenius

M. eriense Tiffany & Ahlstrom. Lake Erie, Tiffany and Ahlstrom, 1931.
M. parvisetum Walton. Mirror Lake, Columbus, Walton, 1930.

M. pusillum Fres. var. *longisetum* Tiffany & Ahlstrom. Lake Erie, Tiffany and Ahlstrom, 1931.

M. radiatum (Chod.) Wille. Buckeye Lake, St. Mary's Lake, Tiffany. 1921

Scenedesmus Meyen

S. abundans (Kirchn.) Chodat. Loramie Lake, St. Mary's Lake, Tiffany, 1921. Lake Erie, Snow, 1902, *(S. caudatus abundans* Kirchn.); Coyle, 1930.

var. *spicatus* (W. & G. S. West) G. M. Smith. Buckeye Lake. Tiffany, 1921.

S. acuminatus (Lag.) Chod. Lake Erie, Snow, 1902, *(Selenastrum acuminatum* Lag.). Loramie Lake; St. Mary's Lake; New Reservoir, Akron, Tiffany, 1921, (also as *Selenastrum acuminatum* Lag.).

S. acutiformis Schröder. Lake Erie, Snow, 1902.

A. arcuatus Lemm. Buckeye Lake, Tiffany, 1921.

var. *platydisca* G. M. Smith. Buckeye Lake, Tffany 1921.

S. armatus (Chod.) G. M. Smith. Buckeye Lake, St. Mary's Lake, Tiffany, 1921.

S. bijuga (Turp.) Lagerheim. Lake Erie, Snow, 1902, *(S. bijugatus* [Turp.] Lag., *S. quadricauda* var. *abundans* Kirchn., *S. quadricaudatus* var. *ecornis* Ehrenb.); Riddle, 1903, *(S. bijugatus* [Turp.] Lag.). Brush Lake, Riddle, 1905, *(S. bijugatus* [Turp.] Lag.) Buckeye Lake; St. Mary's Lake; Chippewa Lake; New Reservoir, Akron, Tiffany, 1921. Ohio River drainage streams, Coyle, 1930.

var. *alternans* (Reinsch) Borge. Lake Erie, Snow, 1902, *(S. alternans* Reinsch).

var. *flexuosus* (Lemm.) Coll. Lake Erie, Snow, 1902. Buckeye Lake, Indian Lake, St. Mary's Lake, Tiffany, 1921.

var. *irregularis* (Wille) G. M. Smith. Buckeye Lake, Tiffany, 1921.

var. *major* Tiffany & Ahlstrom. Lake Erie, Tiffany and Ahlstrom, 1931.

S. brasiliensis Bohlin. Lake Erie, Snow, 1902.

S. carinatus Lemm. Lake Erie, Snow, 1902, *(S. opolensis* var. *carinetus* Lemm.). St. Mary's Lake; New Reservoir, Akron, Tiffany, 1921.

S. denticulatus Lagerh. Buckeye Lake, Indian Lake, Loramie Lake, St. Mary's Lake, Tiffany, 1921. Lake Erie, Coyle, 1930.

S. dimorphus (Turp.) Kütz. Lake Erie, Snow, 1902; Coyle, 1930. Buckeye Lake, Tiffany, 1921. Ohio River drainage streams, Coyle, 1930.

S. longus Meyen. Indian Lake, Tiffany, 1921.

var. *dispar* (Bréb.) G. M. Smith. Buckeye Lake; Tiffany, 1921.

S. obliquus (Turp.) Kütz. Lake Erie, Snow, 1902; (also as *S. acutus* Meyen); Riddle, 1903; Coyle, 1930. Ohio River drainage streams, Coyle, 1930. Springfield, Walton, 1930.

S. opoliensis P. Richter. Lake Erie, Snow, 1902; Coyle, 1930. Buckeye Lake; Indian Lake; St. Mary's Lake; Loramie Lake; New Reservoir, Akron, Tiffany, 1921. Ohio River drainage streams, Coyle, 1930.

S. polymorphus Wood. Granville, Jones, 1887. Jones in Kellerman, 1893. Lake Erie, Vorce, 1881. Kellerman, 1902.

S. quadricauda (Turp.) Bréb. Lake Erie, Vorce, 1881; Snow, 1902, *(S. caudatus* Corda and, *S. quadricaudatus* [Turp.] Bréb.); Riddle, 1903; Coyle, 1930. Granville, Jones, 1887. Brush Lake, Champaign Co., Riddle, 1905. Cincinnati, Twitchell in Kellerman, 1893, *(S. caudatus* Corda). Kellerman, 1902, *(S. quadricaudatus* [Turp.] Bréb.). Indian Lake; Buckeye Lake; Loramie Lake; St. Mary's Lake; Chippewa Lake; New Reservoir, Akron, Tiffany, 1921. Ohio River drainage streams, Coyle, 1930.

var. *longispina* (Chod.) G. M. Smith. Buckeye Lake; New Reservoir, Akron, Tiffany, 1921.

var. *parvus* G. M. Smith. Buckeye Lake, Loramie Lake, Tiffany, 1921. Lake Erie; Ohio River drainage streams, Coyle, 1930.

var. *quadrispina* (Chod.) G. M. Smith. Lake Erie and Ohio River drainage streams, Coyle, 1930.

var. *setosus* Kirchn. Lake Erie, Snow, 1902. *(S. caudatus* Corda var. *setosus* Kirchn.).

*forma *typicus* Kirchn. Kennedy Heights, Cincinnati, March, 1933.

var. *Westii* G. M. Smith. Buckeye Lake, Tiffany, 1921.

Tetrastrum Chodat

T. heterocanthum (Nordst.) Chodat. Lake Erie, Tiffany, and Ahlstrom, 1931.

T. tetracanthum (G. S. West) Brunn. Indian Lake, St. Mary's Lake, Tiffany, 1921.

SIPHONALES

Vaucheriaceae

Dichotomosiphon Ernest

D. tuberosus (A. Br.) Ernest. Lake Erie, Pieters 1901, *(Vaucheria tuberosa* A. Br.).

Vaucheria De Candolle

V. aversa Hassall. Brown, 1929.

V. dichotoma Agardh. Cincinnati, Twitchell in Kellerman, 1893. Kellerman, 1902.

V. geminata (Vauch.) D.C. Painesville, Beardslee, in Kellerman, 1893. Kellerman, 1902. Watson, Cuyahoga Co., 1900. Brown, 1929. Madeira. Mar. 1933.

var. *racemosa* (Vauch.) Walz. Columbus, Eldridge, in Kellerman, 1893. Cuyahoga Co., Watson, 1900. Brown, 1929. Kellerman, 1902.

V. polysperma Hassall. Brown, 1929.

V. pachyderma Walz. Painesville, Beardslee in Kellerman 1893, *(V. Dillwynii* [Web. & Mohr.] Ag.). Kellerman 1902, *(V. Dillwynii* [Web. & Mohr.] Ag.).

V. sessilis (Vauch.) D.C. Logan Co., Cedar Swamp, Urbana; Painesville, Beardslee; Cincinnati, Twitchell in Kellerman, 1893. Kellerman, 1902. Cuyahoga Co., Watson, 1900. Brown 1929. Beaver Pond, Adams Co., April, 1933.

V. terrestris Lyngbye. Cincinnati, Twitchell in Kellerman, 1893. Cuyahoga Co., Watson, 1900. Kellerman, 1902.

ZYGNEMATALES

Zygnemataceae

Mougeotia Agardh

M. calcarea (Cleve) Wittr. Transeau, 1926.
M. genuflexa (Dillw.) Agardh. Painesville, Beardslee in Kellerman, 1893. *(? Pleurocarpus columbianus* var. *minor* Wolle, and *P. mirabilis* A. Br.). Kellerman, 1902, *(M. columbiana* [Wolle] de Toni). Transeau, 1926.
M. laetevirens (Braun) Wittr. Transeau, 1926.
M. notabilis Hassall. Transeau, 1926.
M. nummuloides (Hassall) de Toni. Transeau, 1926.
M. parvula Hassall. Transeau, 1926.
M. quadrangulata. Hassall. Transeau, 1926.
M. robusta (DeBary) Wittr. Transeau, 1926, (also as *M. robusta* var. *biornata* Wittr.).
M. scalaris Hassall. Transeau, 1926.
M. sphaerocarpa Wolle. Mirror Lake, Columbus, Kraatz, 1921. Transeau, 1926.

Spirogyra Link

S. bellis (Hass.) Cleve. Kellerman, 1902. Watson, 1900. Cincinnati, Walton, 1930.
S. cateniformis (Hass.) Kütz. Mirror Lake, Columbus, Kraatz, 1921.
S. communis (Hass.) Kütz. Kellerman, 1902.
S. crassa Kütz. Painesville, Beardslee; Delhi, Twitchell in Kellerman, 1893; Cuyahoga Co., Watson, 1900. Kellerman, 1902. Gambier, Walton, 1930.
S. decimina (Müll.) Kütz. Georgeville, Franklin Co., Bogue; Columbus, Eldridge in Kellerman, 1893; Cuyahoga Co., Watson, 1900.
S. dubia Kütz. Granville, Payne, 1888. Payne in Kellerman, 1893. Cuyahoga Co., Watson, 1900, *(S. dubia longi-articulata* Kütz.). Kellerman, 1902, (also as *S. dubia longi-articulata* Kütz.).
S. elongata (Berk.) Kütz. Cuyahoga Co., Watson, 1900. Kellerman, 1902. (Considered doubtful sp. by Pascher.)
S. fluviatilis Hilso. Granville, Payne, 1888; Payne in Kellerman, 1893, *(S. adnata* Kütz. also). Kellerman, 1902, (also as *S. rivularis* Rabenh. and *S. adnata* Kütz.). Cuyahoga Co., Watson, 1900, (also as *S. rivularis* Rabenh. and *S. adnata* Kütz.).
S. Grevilleana (Hass.) Kütz. Delhi, Twitchell in Kellerman, 1893, Kellerman, 1902.
S. Herrickii Payne. Granville, Payne,, 1888, Payne in Kellerman, 1902. (Pascher lists as questionable; original not accessible.)
S. inflata (Vauch.) Rabenh. Delhi, Twitchell in Kellerman, 1893. Cuyahoga Co., Watson, 1900. Kellerman, 1902.
S. insignis (Hass.) Kütz. Granville, Jones 1887, Jones in Kellerman, 1893. Kellerman, 1902.
S. irregularis Nägeli. Wolle, 1878 (Pascher lists as questionable).
S. Juergensii Kütz. Cuyahoga Co., Watson 1900. Kellerman, 1902, *(S. porticalis Jurgensii.)*

S. longata (Vauch.) Kütz. Delhi, Twitchell in Kellerman, 1893. Cuyahoga Co., Watson, 1900. Kellerman 1902.
S. lutetiana Pet. Cuyahoga Co., Watson, 1900. Kellerman, 1902. (Pascher lists as questionable.)
S. majuscula Kütz. Cuyahoga Co., Watson, 1900. Kellerman, 1902.
S. pellucida (Hass.) Kütz. var. *minor* Tiffany. Near Columbus, Tiffany, 1924.
S. porticalis (Müller) Cleve. Kellerman, 1902. Highland Co., (Cooke, 1932).
S. quinina (Hass.) Kütz. Painesville, Beardslee in Kellerman, 1893. Fairfield Co., Kellerman, 1893. Cuyahoga Co., Watson, 1900. (Pascher lists as questionable.)
S. setiformis (Roth) Kütz. Cuyahoga Co., Watson, 1900. Kellerman, 1902.
S. tenuissima (Hass.) Kütz. Delhi, Twitchell in Kellerman 1893. Kellerman, 1902.
S. varians (Hass.) Kütz. Painesville, Beardslee; Pickway Co., Kellerman, 1893. Kellerman, 1902. Near Newton, April 1933.
S. Weberi Kütz. Granville, Jones 1887; Jones in Kellerman, 1893. Kellerman, 1902. Buckeye Lake, Tiffany, 1921.

Zygnema Agardh

Z. cruciatum (Vauch.) Agardh. Granville, Payne 1888; Payne in Kellerman, 1893. Kellerman, 1902.
Z. insigne (Hass.) Kütz. Painesville, Beardslee in Kellerman 1893. Kellerman, 1902. Madeira, March, 1933. Hamilton Co., 1933.
Z. stellinum (Vauch.) Ag. Granville, Payne 1888, (*Z. stellatum genuinum* Kirchn.); Payne in Kellerman, 1893. (*Z. stellatum genuinum* Kirchn.) Cuyahoga Co., Watson, 1900. Kellerman, 1902.

Zygogonium Kützing

Z. ericetorum Kütz. Transeau, 1933.

Mesotaeniaceae

Gonatozygon DeBary

G. Kinahami (Arch.) Rabenh. Lake Erie, Pieters, 1901.
G. Ralfsii DeBary. Lake Erie, Pieters, 1901.

Netrium (Näg.) Lütkemüller

N. digitus (Ehrenb.) Itzigs. & Rothe. Youngstown, Cushman, 1905.
N. Nägelii (Bréb.) W. & G. S. West. Youngstown, Cushman, 1905.

Spirotaenia Brébisson

S. minutissima Walton. Mansfield, Walton, 1930.

Desmidiaceae

Arthrodesmus Ehrenberg

A. triangularis Lag. Buckeye Lake, St. Mary's Lake, Chippewa Lake, Tiffany, 1921.
var. *subtriangularis* (Borge) W. &. G. S. West, forma *triqueter* G. S. West. Buckeye Lake, Indian Lake, Loramie Lake, St. Mary's Lake; New Reservoir, Akron, Tiffany, 1921.

Closterium Nitzsch

C. acerosum (Schrank) Ehrenb. Granville, Payne, 1888; Payne in Kellerman,

1893. Lake Erie, Snow, 1902; Coyle, 1930. Kellerman, 1902. Brush Lake, Champaign Co., Riddle, 1905. Ohio River drainage streams, Coyle, 1930.

var. *elongatum* Bréb. Ohio River drainage streams, Coyle, 1930.

var. *minus* Hantz. Buckeye Lake; New Reservoir, Akron, Tiffany, 1921. Ohio River drainage streams, Coyle, 1930.

C. acuminatum Kütz. Lake Erie, Riddle, 1903.

C. angustatum Kütz. Lake Erie, Vorce, 1881.

C. cucumis Ehrenb. Lake Erie, Riddle, 1903.

C. decorum Bréb. Youngstown, Cushman, 1905.

C. Dianae Ehrenb. Granville, Jones 1887; Jones in Kellerman, 1893. Lake Erie, Pieters, 1901; Snow, 1902. Kellerman, 1902.

var. *arcuatum* (Bréb.) Rabenh. Lake Erie, Vorce, 1881. Youngstown, Cushman, 1905.

C. Ehrenbergii Menegh. Lake Erie, Pieters, 1901; Snow, 1902. Buckeye Lake, Tiffany, 1921.

C. Ensis Delph. Brush Lake, Champaign Co., Riddle, 1905.

C. lanceolatum Kütz. Lake Erie; Ohio River drainage streams, Coyle, 1930.

C. Leibleinii Kütz. Lake Erie, Pieters, 1901; Snow, 1902. Brush Lake, Champaign Co., Riddle, 1905, Hamilton, Walton, 1930. Ohio River drainage streams, Coyle, 1930.

var. *elatius* Lewin. Lake Erie, Riddle, 1903.

C. lineatum Ehrenb. Granville, Jones 1887; Jones in Kellerman, 1893. Lake Erie, Snow, 1902. Kellerman, 1902.

C. Lunula (Müll.) Nitzch. Lake Erie, Vorce, 1881; Riddle, 1903. Youngstown, Cushman, 1905. Brush Lake, Champaign Co., Riddle, 1905.

var. *intermedium* Gutw. Ohio River drainage streams, Coyle, 1930.

C. moniliferum (Bory) Ehrenb. Granville, Jones, 1887; Jones in Kellerman, 1893. Kellerman, 1902. Brush Lake, Champaign Co., Riddle, 1905. Youngstown, Cushman, 1905. Lake Erie; Ohio River drainage streams, Coyle, 1930.

C. parvulum Nägeli. Granville, Jones, 1887; Jones in Kellerman, 1893. Kellerman, 1902. Lake Erie, Pieters, 1901. Brush Lake, Champaign Co., 1905. St. Mary's Lake, Tiffany. 1921.

C. peracerosum (Bory) Gay. Lake Erie; Ohio River drainage streams, Coyle, 1930.

C. pronum Bréb. Lake Erie, Snow, 1902. Buckeye Lake, Tiffany, 1921. Ohio River drainage streams, Coyle, 1930.

†var. *acutum* Klebs. Lake Erie, Snow, 1902.

†var. *linea* Klebs. Lake Erie, Snow, 1902.

C. setaceum Ehrenb. Lake Erie, Vorce, 1881.

C. strigosum Bréb. Granville, Jones 1887; Jones in Kellerman, 1893. Kellerman, 1902. Lake Erie, Riddle, 1903.

C. striolatum Ehrenb. Youngstown, Cushman, 1905.

C. Ulna Focke. Ohio River drainage streams, Coyle, 1930.

C. Venus Kütz. Lake Erie, Vorce, 1881; Pieters, 1901.

Cosmarium Corda

C. sp. Lake Erie, Pieters, 1901, *(Pleurotaeniopsis Ralfsii* [Bréb.] Lund.) 1903; Riddle, *(Disphinctum mutabile* [Bréb.] Hansg.).

C. adoxum W. & G. S. West. Ohio River drainage streams, Coyle, 1930.

+*C. Amesii* Cushman. Youngstown, Cushman, 1905.

+*C. angulare* Johnson. Lake St. Clair, Pieters, 1901.

C. bireme Nordst. Ohio River drainage streams, Coyle, 1930.

C. biretum Bréb. Granville, Jones, 1887; Jones in Kellerman, 1893. Kellerman, 1902. Brush Lake, Champaign Co., Riddle, 1905.

var. *floridense* Wolle. Lake Erie, Riddle, 1903.

C. Blytii Wille. Lake Erie, Riddle, 1903.

C. Botrytis (Bory) Menegh. Granville, Jones, 1887; Jones in Kellerman, 1893. Lake Erie, Riddle, 1903. Brush Lake, Champaign Co., Riddle, 1905. Kellerman, 1902.

C. Brebisonii Menegh. Granville, Jones, 1887; Jones in Kellerman, 1893. Lake Erie, Pieters, 1901. Kellerman 1902. Brush Lake, Riddle 1905.

+*C. Broomei* Thwaites. Granville, Jones, 1887; Jones in Kellerman, 1893. Lake Erie, Riddle, 1903. Youngstown, Cushman, 1905. Kellerman, 1902.

+*C. coelatum* Ralfs. Lake Erie, Riddle, 1903.

C. connatum Bréb. Lake Erie, Pieters, 1901, *(Disphinctum connatum* [Bréb.] DeBary).

C. contrastum Kirchn. Granville, Jones 1887; Jones, in Kellerman, 1893. Lake Erie, Riddle, 1903. Kellerman, 1902.

C. crenatum Ralfs. Lake Erie, Snow, 1902.

C. cyclicum Lund. Youngstown, Cushman, 1905.

C. cymatoplerum Nordst. Ohio River drainage streams, Coyle, 1930.

C. depressum (Näg.) Lund. Lake Erie, Pieters, 1901.

C. didymochondrum Nordst. Lake Erie, Coyle, 1930.

C. garrolense Roy. & Biss. Lake Erie; Ohio River drainage streams, Coyle 1930.

C. granatum Bréb. Lake Erie, Pieters, 1901; Snow, 1902; Riddle, 1903.

C. intermedium Delp. Granville, Jones, 1887; Jones in Kellerman, 1893. Kellerman, 1902. Lake Erie, Riddle, 1903.

+*C. Kjellmanii* Wille. Lake Erie, Snow, 1902.

C. latum Bréb. Granville, Jones 1887; Jones in Kellerman, 1893. Kellerman, 1902.

C. leve Rabenh. Lake Erie, Pieters, 1901; Coyle, 1930. Indian Lake, Loramie Lake, St. Mary's Lake, Chippewa Lake, Tiffany, 1921. Ohio River drainage streams, Coyle, 1930.

var. *septentrionale* Wille. Lake Erie, Riddle, 1903.

C. logiense Biss. Lake Erie Coyle, 1930.

C. margaritiferum (Turp.) Menegh. Lake Erie, Pieters, 1901; Riddle, 1903. Brush Lake, Champaign Co., Riddle, 1905. Chippewa Lake, Tiffany, 1921.

C. Meneghinii Bréb. Lake Erie, Pieters, 1901; Snow, 1902.

var. *angulosum* (Bréb.) Rabenh. Ohio River drainage streams, Coyle, 1930.

var. *concinnum* Rabenh. Lake Erie, Snow, 1902.
C. moniliforme (Turp.) Ralfs. Lake Erie, Pieters, 1901.
C. nitidulum De Not. Lake Erie, Pieters, 1901. Brush Lake, Champaign Co., Riddle, 1905.
C. obtusatum Schmidle. Ohio River drainage streams, Coyle 1930.
C. orbiculatum Ralfs. Granville, Jones, 1887; Jones in Kellerman, 1893. Kellerman, 1902. Lake Erie, Riddle, 1903.
C. ornatum Ralfs. Lake Erie, Riddle, 1903; Pieters, 1901.
C. pardalis Cohn. Lake Erie, Riddle, 1903.
C. portianum Archer. Lake Erie, Pieters, 1901; Riddle, 1903.
C. pseudopyramidatum Lund. Youngstown, Cushman, 1905.
C. punctulatum Bréb. Lake Erie, Pieters, 1901; Snow, 1902.
C. pygmaeum Archer. Lake Erie, Snow, 1902.
C. pyramidatum Bréb. Ohio River drainage streams, Coyle 1930. Madeira. March, 1933.
C. radiosum Wolle. Buckeye Lake, Tiffany, 1921.
C. Ralfsii Bréb. Granville, Jones, 1887; Jones in Kellerman, 1893. Lake Erie, Snow, 1902. Kellerman, 1902.
+var. *typicum* Ralfs. Lake Erie, Snow, 1902.
C. Regnellii Wille. Buckeye Lake, Tiffany, 1921.
C. reniforme (Ralfs) Archer. Lake Erie, Pieters, 1901; Snow, 1902. Ohio River drainage streams, Coyle 1930.
var. *compressa* Nordst. Lake Erie, Pieters, 1901.
C. Seelyanum Wolle. Granville, Jones 1887; Jones in Kellerman, 1893. Kellerman, 1902.
C. speciosum Lund. var. *simplex* Nordst. Lake Erie; Ohio River drainage streams, Coyle, 1930.
C. subcostatum Nordst. Indian Lake, Tiffany, 1921.
C. subcrenatum Hantzsch. Lake Erie, Riddle, 1903.
C. subnotabile Wille. Loramie Lake, Tiffany, 1921.
C. suborbiculare Wood. Lake Erie, Riddle, 1903.
C. tenue Archer. Chippewa Lake, St. Mary's Lake, Tiffany, 1921.
C. tetraopthalmum (Kütz.) Bréb. Lake Erie, Snow, 1902.
C. tinctum Ralfs. Granville, Jones, 1887; Jones in Kellerman, 1893. Lake Erie, Snow, 1902. Kellerman, 1902.
C. Turpinii Bréb. Youngstown, Cushman, 1905.
C. undulatum Corda. Chippewa Lake, Tiffany, 1921.
var. *minutum* Wittr. Lake Erie, Coyle 1930.

Desmidium Agardh

D. aptogonium Bréb. Lake Erie, Riddle, 1903. Brush Lake, Champaign Co., Riddle, 1905.
D. Swartzii Agardh. Granville, Payne, 1888; Payne in Kellerman, 1893. Lake Erie, Pieters, 1901, Kellerman, 1902.

Docidium Brébisson

+*D. trabecula* (Ehrenb.) Näg. Granville, Jones, 1887; Jones in Kellerman, 1893.

Euastrum Ehrenberg.

E. binale (Turp.) Ralfs. Lake Erie, Pieters, 1901; Snow, 1902.

E. elegans, (Bréb.) Kütz. Granville, Jones, 1887; Jones in Kellerman, 1893. Lake Erie, Pieters, 1901; Riddle, 1903. Kellerman, 1902. Buckeye Lake; New Reservoir, Akron, Tiffany, 1921.

E. rostratum Ralfs. Granville, Jones, 1887; Jones in Kellerman, 1893. Kellerman, 1902.

E. verrucosum Ehrenb. Lake Erie, Snow, 1902. Youngstown, Cushman, 1905.

Hyalotheca Ehrenberg

H. dissiliens (Smith) Bréb. Lake Erie, Pieters, 1901; Snow, 1902; Riddle 1903. Brush Lake, Champaign Co., Riddle, 1905. Ohio River drainage streams, Coyle, 1930.

H. mucosa (Mert.) Ehrenb. Granville, Payne, 1888; Payne in Kellerman, 1893. Kellerman, 1902. Lake Erie, Pieters, 1901.

Micrasterias Agardh

M. americana (Ehrenb.) Ralfs. (Form?) Youngstown, Cushman, 1905.

M. truncata (Corda) Bréb. Granville, Payne, 1888; Jones 1887; Jones and Payne in Kellerman, 1893. Kellerman, 1902.

Onychonema Wallich

O. filiforme (Ehrenb.) Roy & Biss. Granville, Jones 1887; Jones in Kellerman, 1893, *(Sphaerozosma filiforme* Rabenh.). Lake Erie, Snow, 1902, *(Sphaerozosma filiforme* Rabenh.). Kellerman, 1902, *(Onochronema filiforme* [Ehr.] Roy and Biss.)

O. laeve Nordst.

+var. *minus.* Lake Erie, Snow, 1902.

Penium Brébisson

P. margaritaceum (Ehrenb.) Bréb. Ohio River drainage streams, Coyle, 1930.

+var. *obesum* Cushman. Youngstown, Cushman, 1905.

Pleurotaenium Nägeli

P. coronatum (Bréb.) Rabenh.

var. *nodulosum* (Bréb.) Mert. Youngstown, Cushman, 1905.

P. Ehrenbergii (Ralfs) Delf. Ohio River drainage streams, Coyle, 1930.

P. Trabecula (Ehrenb.) Näg. Lake Erie, Pieters, 1901; Snow, 1902; Riddle, 1903. Kellerman, 1902. Brush Lake, Champaign Co., Riddle, 1905. Buckeye Lake, Tiffany, 1921. (form.?)

+var. *clavata* (Kütz.) West. Youngstown, Cushman, 1905.

var. *rectum* (Delp.) West. Youngstown, Cushman, 1905.

Staurastrum Meyen

S. anatinum Cooke & Wille. Granville, Jones 1887; Jones in Kellerman, 1893 Kellerman, 1902.

S. aspinosum Wolle. Lake Erie, Riddle, 1903.

S. aversum Lund. Lake Erie, Riddle, 1903.

S. Avicula Bréb. Lake Erie, Pieters, 1901.

S. Brebissoni Arch. Lake Erie, Pieters, 1901.

+*S. crenulatum* (Näg.) Delp. Lake Erie, Pieters, 1901; Snow, 1902.
S. cyclacanthum W. & G. S. West. Buckeye Lake; St. Mary's Lake; Indian Lake; New Reservoir, Akron, Tiffany, 1921.
S. dejectum Bréb. Lake Erie, Pieters, 1901.
+*S. digitatum* Lake Erie, Vorce, 1881.
S. dilatatum Ehrenb. Lake Erie, Pieters, 1901.
S. furcigerum Bréb. Lake Erie, Pieters, 1901.
S. fusiforme Wolle. Brush Lake, Champaign Co., Riddle, 1905.
S. gracile Ralfs. Lake Erie, Vorce, 1881; Snow, 1902.
S. grallatorium Nordst. Lake Erie, Riddle, 1903.
S. inconspicuum Nordst. Granville, Jones 1887; Jones in Kellerman, 1893. Kellerman, 1902.
S. leptocladium Nordst. Brush Lake, Champaign, Co., Riddle, 1905.
var. *elegans* G. S. West. St. Mary's Lake, Tiffany, 1921.
S. muticum Bréb. Youngstown, Cushman, 1905.
var. *depressum* (Näg.) Boldt. Lake Erie, Riddle, 1903.
S. oblongum Delp. Lake Erie, Snow, 1902.
S. paradoxum Meyen. Lake Erie, Ohio River drainage streams, Coyle, 1930
S. pentacladium Wolle. Lake Erie, Riddle, 1903.
S. polymorphum Bréb. Granville, Jones 1887; Jones in Kellerman, 1893. Lake Erie, Snow, 1902; Riddle, 1903. Kellerman, 1902.
+var. *Chaetoceras* Schröd. Lake Erie, Snow, 1902.
S. pseudopachyrynchum Wolle. Granville, Jones, 1887; Jones in Kellerman, 1893.
S. punctulatum Bréb. Lake Erie, Pieters, 1901. Youngstown, Cushman, 1905.
S. striolatum (Näg.) Archer. Lake Erie, Pieters, 1901; Snow, 1902.
S. teliferum Ralfs. Lake Erie, Snow, 1902.
S. tetracerum (Kütz.) Ralfs. Lake Erie, Pieters, 1901.

Tetmemorus Ralfs

T. levis (Kütz.) Ralfs. (Forma?) Youngstown, Cushman, 1905.

Xanthidium Ehrenberg.

X. hastiferum Kütz. Lake Erie, Pieters, 1901, *(X. antilopaeum* Kütz.).

Dinophyceae

DINOFLAGELLATAE

Ceratium Schrank

C. hirundinella (O. F. M.) Schrank. Rock Bottom Ponds, Krecker, 1919. Buckeye Lake, Tiffany, 1921.

Peridinium Ehrenberg

P. aciculiferum Lemm. Buckeye Lake, Indian Lake; Loramie Lake; St. Mary's Lake; Chippewa Lake; New Reservoir, Akron, Tiffany, 1921. Ohio River drainage streams. Coyle, 1930.
P. bipes Stein. Mirror Lake, Columbus, Walton, 1930.
P. inconspicuum Lemm. Ohio River drainage streams, Coyle, 1930.
**P. Willei* Huitfeldt-Kaas. Burnet Woods Lake, Cincinnati, (Hoskins, 1932.)

Euglenophyceae

EUGLENALES

Euglenaceae

Cryptoglena Ehrenberg

C. pigra Ehrb. Lake Erie, Walton, 1915.

Euglena Ehrenberg

E. Acus Ehrenb. Mt. Vernon; Milford Center; Sandusky, Walton, 1915. Ohio River drainage streams, Coyle, 1930.
E. acutissima Lemm. Fremont, Walton, 1915.
E. deses Ehrenb. Gambier, Walton, 1915.
E. fusca (Klebs) Lemm. Ohio River drainage streams, Coyle, 1930.
E. geniculata Dujard. Storage Dam, Columbus, Walton, 1915.
E. oxyuris Schmarda. Gambier, Lake Erie, Walton, 1915. Buckeye Lake, Indian Lake, Loramie Lake, Tiffany, 1921.
E. pisciformis Klebs. Ohio River drainage streams, Coyle 1930.
var. *minor* Hansg. Gambier, Walton, 1915.
E. polymorpha Dang. Mirror Lake, Walton, 1915.
E. proxima Dang. Storage Dam. Columbus, Walton, 1915.
E. sanguinea Ehrenb. Lake Erie, Walton, 1915.
E. simulacra Walton. Fremont, Walton, 1915.
E. Spirogyra Ehrenb. Gambier, Lake Erie, Walton, 1915; Coyle, 1930. Buckeye Lake, Indian Lake, Loramie Lake, St. Mary's Lake, Chippewa Lake, Akron, Tiffany, 1921.
var. *laticlavia* (Huber) Lemm. Ohio River drainage streams, Coyle 1930.
var. *marchia* Lemm. Ohio River drainage streams, Coyle 1930.
E. spiroides Lemm. Lake Erie, Ohio River drainage streams, Coyle, 1930.
E. torta Stokes. Milford Center, Walton, 1915.
E. tripteris (Dujard.) Klebs. Gambier, Milford Center, Walton, 1915.
E. truncata Walton. Mt. Vernon, Walton, 1915.
E. variabilis Klebs. Gambier, Walton, 1915.
E. velata Lemm. Gambier, Walton, 1915.
E. viridis Ehrenb. Cincinnati, Twitchell in Kellerman, 1893. Columbus, Werner in Kellerman, 1893. Kellerman, 1902. Mt. Vernon, Gambier, Walton, 1915. Rock Bottom Pond, Krecker, 1919. Hamilton Co., (Cooke, 1933.) Muddy Creek, Hamilton Co., April, 1934.

Eutreptia Perty

E. ovata Walton. Gambier, Walton, 1930.

Lepocinclis Perty

L. acicularis Francé. Cincinnati, Walton, 1915.
L. Ovum (Ehrenb.) Lemm. Lake Erie, Walton, 1915.
L. teres (Schmitz) Francé. Gambier, Walton, 1915.
L. texta (Duj.) Lemm. Gambier, Walton, 1915.

Menoideum Perty

***M. pellucidum* Perty. Kennedy Heights, Hamilton Co., April, 1933.

Phacus Dujardin

P. acuminata Stokes. Storage Dam, Columbus, Walton, 1915.

P. longicauda (Ehrenb.) Duj. Lake Erie, Gambier, Walton, 1915. Buckeye Lake, Indian Lake, Chippewa Lake, Akron, Tiffany, 1921. Ohio River drainage streams, Coyle, 1930. Kennedy Heights, Hamilton Co., April, 1933.

P. orbicularis Hübner. Mt. Vernon, Walton, 1915.

P. oscillans Klebs. Storage Dam, Columbus, Walton, 1915.

P. Pleuronectes (O. F. M.) Duj. Lake Erie, Walton, 1915. Buckeye Lake. Indian Lake, Loramie Lake, Chippewa Lake, Tiffany, 1921. Ohio River drainage streams, Coyle, 1930.

P. pyrum (Ehrenb.) Stein. Gambier, Walton, 1915.

P. triqueter (Ehrenb.) Duj. Gambier, Mt. Vernon, Lake Erie, Walton, 1915. Ohio River drainage streams, Coyle, 1930.

Trachelomonas Ehrenberg

T. americana Lemm. Mirror Lake, Walton, 1915.

T. crebea Kellicott. Walton, 1915.

T. globularis (Awering) Lemm. Gambier, Cincinnati, Walton, 1915.

T. hispida (Perty) Stein. Lake Erie, Hamilton, Walton, 1915.

T. oblonga Lemm. Columbus, Walton, 1915.

T. rugulosa Stein. Columbus, Walton, 1915.

T. spinosa Stokes. Akron, Walton, 1915.

T. teres Maskell. Cincinnati, Walton, 1915.

T. volvocina Ehrenb. Lake Erie, Gambier, Walton, 1915.

Colaciaceae

Colacium Ehrenberg

C. calvum Stein. Lake Erie, Walton, 1915.

C. vesiculosum Ehrenb. Columbus, Lake Erie, Walton, 1915.

Peranemaceae

Peranema Dujardin

P. trichophorum (Ehrenb.) Stein. Mansfield, Walton, 1930.

Charophyta

CHARACEAE

Nitelleae

Nitella Agardh.

N. batrachosperma (Reinsch) A. Br. Lake Erie, Pieters, 1901.

N. flexilis (L.) Ag. Riddell, 1834. Cincinnati, James, 1879. O. J. Clark in Kellerman 1893; Painesville, Werner in Kellerman 1893. Kellerman, 1902. (All as *Chara flexilis* Desv.).

N. gracilis (Smith) Ag. Lake Erie, Pieters, 1901, (vel sp. *affinis*).

N. polyglochin A. Br. Lake Erie, Pieters, 1901.

N. subglomerata A. Br. Lake Erie, Pieters, 1901.

N. tenuissima (Desv.) Cosson & Germain. Painesville, Werner in Kellerman, 1893. Lake Erie, Pieters, 1901.

Tolypella (A. Br.) Leonhardi

T. intertexta Allen. Lake Erie, Pieters, 1901.

Chareae

Chara Vaillant

C. aspera (Dethard) Wild. Lake Erie, Pieters, 1901.

C. contraria A. Br. Champaign Co., Werner, Columbus; Wilcox, in Kellerman 1893. Lake Erie, Pieters, 1901, (also formae *elongata, gymnotiles, macroptila, macrotiles, microptila, paregymnophylla, subinermis).* Kellerman. 1902.

C. coronata Ziz. Loveland, James, 1884. Clermont Co., James; Painesville, Werner, in Kellerman, 1893. Lake Erie, Pieters, 1901, (also formae *incrassata, meiocarpa, meioptila).*

C. haitensis Turpin. Dayton, Riddell?, 1834, *(C. sabulosa* Riddell). Braun, 1884, *(C. Michauxii).* Painesville, Werner in Kellerman, 1893, *(C. gymnopus Michauxii* A. Br.). Lake Erie, Pieters, 1901, *(C. gymnopus Michauxii* A. Br.). Kellerman, 1902.

C. hyropitys Reichenbach. Lake Erie, Pieters, 1901, (forma *compacta).*

C. intermedia A. Br. Champaign Co., Werner, Springfield; Wilcox in Kellerman, 1893. Lake Erie, Pieters, 1901. (This sp. is listed by Robinson [1905] as not recorded authentically from the U. S.).

C. sabulosa Riddell var. *spiralis* Riddell. Dayton, Riddell, 1834. (Robinson [1905] lists this variety as questionable, known only from Riddell [1834]).

C. sejuncta A. Br. Lake Erie, Pieters, 1901.

C. squamosa Desf. var. *foliosa* Wille. Old River, Hamilton; Oolentangy River, Worthington, Riddell, 1834. (Robinson lists this variety as questionable.)

C. vulgaris L. Riddell, 1834. (also ? *C. humilis* Riddell). Champaign Co., Werner, *(C. foetida* A. Br.); Painesville, Werner, *(C. fragilis* Desv.) in Kellerman, 1893. Kellerman 1902, *(C. fragilis* Desv. and *C. foetida* A. Br.). Lake Erie, Pieters, 1901, *(C. fragilis* Desv., also *C. fragilis* formae *brevibracteata, subinermis).*

II. ALGAE FROM KENTUCKY

Myxophyceae

CHROOCOCCALES

Chroococcaceae

Chroococcus Nägeli

C. giganteus W. West. Cumberland Falls, Whitley Co. May 1933.

Gloeocapsa Kützing

G. granosa (Berk.) Kütz. Cumberland Falls, Whitley Co., May 1933.

HORMOGONIALES

Oscillatoriaceae

Oscillatoria Vaucher

O. Agardhii Gom. Boone Co., April, 1933.

O. articulata Gardner. Cumberland Falls, Whitley Co., May, 1933.

O. Boryana Bory. Boone Co., April, 1933.

O. irrigua Kütz. Boone Co., April, 1933.

Nostocaceae
Nostoc Vaucher
N. comminutum Kütz. Cumberland Falls, Whitley Co., May, 1933.
N. paludosum Kütz. Cumberland Falls, Whitley Co., May, 1933.

Stigonemataceae
Stigonema Agardh
S. hormoides (Kütz.) Born. & Flah. Cumberland Falls, Whitley Co., May, 1933.

Rivulariaceae
Calothrix Agardh
C. sp. Cumberland Falls, Whitley Co., May 1933.

Rhodophyceae
Florideae
NEMALIONALES
Batrachospermaceae
Batrachospermum Roth
B. moniliforme Roth. Natural Bridge, Powell Co., (Povah, May, 1930). (See Ohio List.)

Heterokontae
HETEROTRICHALES
Tribonemataceae
Tribonema Derbes & Solier
T. bombycinum (Ag.) Derb. & Sol. Boone Co., April 1933.

HETEROSIPHONALES
Botrydiaceae
Botrydium Wallroth
B. granulatum (L.) Grev. Boone Co., (Fulford and Baur, May, 1933).

Chlorophyceae
ULOTRICHALES
Microsporaceae
Microspora Thuret
M. stagnorum (Kütz.) Lagerh. Cumberland Falls, Whitley Co., 1933.

Cladophoraceae
Cladophora Kützing
C. callicoma Kütz. Boone Co., 1933.

OEDOGONIALES
Oedogoniaceae
Oedogonium Link
O. crassiusculum Wittr. Cumberland Falls, Whitley Co., 1933.

CHLOROCOCCALES
Hydrodictyaceae
Pediastrum Meyen
P. Boryanum (Turp.) Menegh. Ft. Thomas, Campbell Co., (Hess, 1933).

Scenedesmaceae

Scenedesmus Meyen

S. obliquus (Turp.) Kütz. Ft. Thomas, Campbell Co., (Hess, 1933).

S. quadricauda (Turp). Bréb. Ft. Thomas, Campbell Co., (Hess, 1933).

forma *typicus* Kirchn. Ft. Thomas, Campbell Co., (Hess, 1933)

ZYGNEMATALES

Desmidiaceae

Cosmarium Corda

C. granatum Bréb. var. *subgranatum* Nordst. Ft. Thomas, Campbell Co., (Hess, 1933).

Penium Brébisson

P. navicula Bréb. Ft. Thomas, Campbell Co., (Hess, 1933).

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CONCERNING "LAKE BALLS," "CLADOPHORA BALLS" AND "COAL BALLS."[1]

E. M. KINDLE

It is proposed in this paper to compare two not very widely known organic structures found in certain lakes with analogous Coal Measure structures which are noted for the exceptional perfection of preservation which characterizes the fossil plant remains composing them. It is believed that such a comparison may be helpful in understanding the origin of Coal balls just as would be the comparison of recent tide flat mud-crack and fossil mudcrack, if the origin of the latter was obscure or in dispute.

Lake Balls: Ball shaped structures composed chiefly of aggregations of various kinds of plants or plant fragments and sometimes a variety of other materials occur in certain lakes. They are not found in most lakes though apparently common in localities where they do occur. Few references to them have come to the writer's notice in papers dealing with American lakes. The earliest of these appears in Thoreau's Walden (1889 [?], p. 205). In Flint's or Sandy pond near Concord, Mass., Thoreau found "curious balls, composed apparently of fine grass or roots, of pipewort perhaps, from half an inch to four inches in diameter, and perfectly spherical. These wash back and forth in shallow water on a sandy bottom, and are sometimes cast on the shore. They are either solid grass, or have a little sand in the middle. At first you would say that they were formed by the action of the waves, like a pebble; yet the smallest are made of equally coarse materials, half an inch long, and they are produced only at one season of the year. Moreover the waves, I suspect, do not so much construct as wear down a material which has already acquired consistency. They preserve their form when dry for an indefinite period." [2]

This careful description based on observations made by Thoreau about 1845 on what appears to be a rarely observed or described lake product, indicates that the "lake balls" known to him were formed on sandy bottom and sometimes had a nucleus of sand. The ripple marks found near them appear to suggest that both are products of wave action which makes balls out of vegetable débris while it moulds the sand grains into ripple ridges.

More than 50 years after the publication of Thoreau's description of vegetable balls, W. F. Ganong (1907, pp. 304-306), described similar structures from Little Kedron Lake, N. B., "composed chiefly of leaves of fir and spruce but with some other vegetable matter such as small twigs, etc., in addition all interlocked together." These balls which had a maximum diameter of 6″ to

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1 Published with the permission of the Director, Geological Survey of Canada, Department of Mines, Ottawa. This paper was presented at the Washington meeting of the International Geological Congress in 1933.

2 Prof R. H. Wetmore of Harvard Univ. examined the shore of Sandy Pond at my request, but failed to find specimens of "Lake Balls," probably because the pond is now a reservoir, with consequent changes in the character of the shore.

8″ were considered to be probably a product of wave action. Ganong's figures of these balls are here reproduced.

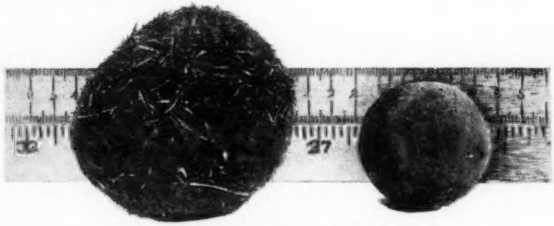

Fig. 1. "Lake balls" figured by Ganong.

Burr Balls. That on the left is from Little Kedron Lake, that on the right is a small specimen from Flint, or Sandy, Pond, in Massachusetts. The upper ruler shows centimetres, and the lower shows inches. (About one-third the true size).

In other papers Ganong (1905, p. 45; 1909, p. 151) assembled several other records of "Lake balls." These structures from an Idaho lake are described as follows:

Balls and solid cylinders composed, in the main, of decaying pine needles, bits of comminuated bark and wood, *Ceratophyllum demersum*, leaves and stems of Potamogeta, Charas and Nitellas are of common occurrence in Lake Pend Oreille, in Idaho, and doubtless in Priest and Coueur d'Alene lakes also, in the same State. The wave motion rolls the mixture along the bottom and in its progress shoreward pine needles, decaying splinters of wood, bark and similar debris are taken up and become intimately mixed with the primary mass. Infusorial—slimes—Amoebas, Verticellas, etc.—develop and assist in holding the mass together.

Another record (1909, p. 151) relates to balls composed almost wholly of hair.

The hair comes from a tannery located on the shore of Lake Michigan a mile or two north of Petoskey, at a point called Kegomic and these hair balls are cast up on the beach about a mile further along, although a few are found at other places around the bay. . . . The hair balls are of all sizes up to at least five inches in diameter, although my recolletion is that balls of that size are much less common than smaller ones.

Vegetable balls have been reported from two Nova Scotia lakes by A. H. MacKay (1908, pp. 667-670) but the specimens figured by him are "sea balls" and were found on the sea shore at Upper Kingsburg, Lunenburg county.

Nova Scotia has also furnished a unique variety of vegetable ball formed by a brook in a pool at the foot of a small waterfall. The only described examples[3] known to me were exhibited at a meeting of the Ottawa Field Naturalist's club in 1903 and described by A. E. Atwood (1903, p. 41) as follows:

Vegetable concretions or nodules from Nova Scotia. These were several inches in diameter and almost spherical in shape. They had been formed by the matting or felting together of small pieces of grass, ferns, and pine leaves through the action of water in a pool at the foot of a small waterfall on a rivulet.

3 This record was brought to my notice by Mr. A. LaRocque.

W. L. McAtee (1925, p. 299) has assembled under the title of "water formed vegetable balls" several of the vernacular names in use for these structures in various parts of the world. The English terms cited by him are burr balls, sea balls, vegetable balls and water-rolled weed balls. He puts on record still another term,—"Buffalo balls" which is used for the balls of peculiar composition observed at certain lakes in the western United States.

> These "Buffalo Balls" as they are locally called were very abundant in August, 1917, along the shore of one lake near Dawson, North Dakota. Large masses of detached *Ruppia maritima* were observed floating in the water, churned up with a goodly amount of the foam which is readily produced in this alkaline water. Continual wave action apparently resulted in the formation of the balls which were washed up on shore in sufficient number to make two or three wagon loads. These balls were variable in size, from about 1½ inches in diameter to somewhat over 3 inches; they were rarely spherical, usually being somewhat longer in one diameter and often flattened. They were composed entirely of stems peduncles and seeds of *Ruppia maritima*, all bound closely together in a solid, firm mass; the surface was fairly smooth and often incrusted with small white spots of crystallized salts and occasional fragments of algae. Similar balls have been reported from Miller Lake, Oregon, by Dr. George W. Field.

Numerous other references to the structures here called lake balls or allied structures may be found in a paper by Schroder (1920, pp. 799-803).

None of the vernacular terms in use are adequate to include all of the structures described by the authors cited. The thousands of balls formed by salmon bones carried down by the Karluk river Alaska reported by McAtee (1925, p. 299) might appropriately be called River balls and for the vegetable balls here under consideration Lake balls seems to be a suitable name.

These rather rare ball-like structures usually composed of a variety of plants represent a product of wave action with which probably few geologists are acquainted. Since they are products of wave action they must have been produced in Carboniferous times about as frequently from the abundant forest débris of Coal Measure lakes as they are in modern lakes.

Cladophora balls: There is another type of vegetable lake ball which is the result of the growth of one kind of plant. The best known lake balls of this type are called by algal botanists "Cladophora balls" after the name of the genus of algae responsible for them. Their globular shape is regarded as the result of the peculiarities of the growth habits of the algae represented, operating under the influence of wave or current action. Concerning the formation of these structures and their rare occurrence in the United States Professor G. M. Smith (1933, pp. 430-431) writes as follows:

> Cladophora balls are irregular inshape when first formed and with the filaments irregularly intertwined. Growth of the filaments that have been rolled into a ball is largely radial. The continued abrasion of the plant mass, as it swishes back and forth across the sandy bottom, results in its assuming a globular form. As the ball continues to increase in size, there is often a death and decay of the filaments at the center of the ball. Gases given off during photosynthesis may accumulate in this cavity and cause the balls to rise to the surface of the lake. Cladophora balls are common in certain lakes of Europe. They seem to be of rare occurrence in this country and are definitely known only from a lake in Massachusetts.

The single reported American occurrence of Cladophora balls reported by Smith is credited to F. S. Collins.

During the early part of the summer of 1932 the writer discovered what

appears to be the first reported Canadian occurrence of "Cladophora balls." They were found in considerable numbers along a sandy beach on the northwest side of Lake Doré, Ontario, about a mile above the outlet, June 20th. (See Figure 2). Although found abundantly at Lake Doré, in both 1932 and 1933 they have not been encountered elsewhere by the writer who has examined the shores and bottoms of various Ottawa valley lakes with some care. This seems to indicate that Cladophora balls are rare in the Ottawa valley. There appears to be no previous record of their occurrence in Canada. The balls from Lake Doré were sent to Professor Lowe of the University of Manitoba who determined them as *Cladophora (Aegagropila) balsatica* Kütz. These balls occurred along the edge of a sandy beach adjacent to an area where yellow pond lilies and other shoal water plants [4] occupied an acre or more of the shoal water. The abundance of the balls on the shore adjacent to this yellow pond lily asemblage and behind it appeared to indicate that the balls originated on the bottom in the midst of the water plant assemblage. Search for these on the lake bottom resulted in finding them abundant in places on patches of the bottom a few feet square. The maximum water temperature observed at this locality was 78°F. The west short of Lake Doré was revisited on July 16th when air temperature was 78° and water 76° when the Cladophora balls were found to be much less abundant than they were on June 20th.

The balls serve as hosts to a considerable variety of life. One of the most common of these parasitic forms apparently represents a stage of a species of the insect family Chironomidae (Diptera, flies).[5] Mr. Douglas Leechman who has kindly studied some of the microscopic and other forms of life associated with these balls has supplied the following list of the plant and animal life to which the balls serve as host:

DIATOMS

Cyclotella sp.
Tabellaria sp. and many others

DESMIDS

Closterium sp.
Cosmarium sp.

OTHER ALGAE

Spirogyra sp.
Pediastrum sp.

SARCODINA

Amoeba proteus
Amoeba guttula
Amoeba radiosa
Amoeba limax
Centropyxis aculeata
Arcella vulgaris
Euglypha sp.
Actinophrys sol

INFUSORIA

Dileptus gigas
Halteria sp.
Stylonychia sp.
Holosticha sp.
Vorticella limnetis
Vorticella monilata

NEMATODA

One species, not identified

ROTATORIA

Euchlanis sp.
Colurus sp.

GASTROTRICHA

Chaetonotus

INSECTA

Chironomus, larvae
Pupae of a dipterous insect

MISCELLANEOUS

Pollen of a conifer

4 Determined by Dr. M. O. Malte as follows: *Pontederia cordata* L., *Scirpus validus* Vahl, *Myriophyllum* sp., *Potamogeton heterophyllum* Schreb., *Ceratophyllum demersum* L.

5 Communicated by Arthur Gibson, Dominion Entomologist.

"Cladophora balls" described by Barclay (1885-6, pp. 845-848) under the name of Algoid lake balls from a lake on one of the Hebrides Islands are reported to have an outer coat of algal filaments of felt like consistency from 1/20 to 2/20 of an inch in thickness; inside this outer shell the naked eye could see only mud which the microscope showed to be filled with diatoms and the decomposed remains of the inner ends of the radiating filaments. These balls range from a quarter of an inch up to three or four inches in diameter and occurred in great numbers at a point where the water is occasionally rendered brackish by the tide. In some cases a complete ball is found inside a larger one. Barclay was unable to find any evidence of the occurrence of these balls elsewhere in Scotland, but learned that they were known in certain lakes in Norway, Northern Germany, Austria and Upper Italy and also in the sea. The mud filled interiors of some of the balls described by Barclay and the decayed interiors of the "cladophora balls" collected by the writer with their varied assemblage of animal and plant species in parasitic association might under certain favorable conditions be preserved as concretions or concretion-like forms. Such nodules with their fosilized parasitic assemblages of sediments apparently free from such fossils would supply the geologist with a puzzle comparable with that which a "coal ball" sometimes presents to the palaeobotanist.

Some of the more interesting later studies of "Cladophora balls' made by leading students of them have been summarized by Elizabeth Acton, (1916, p. 9) who kept "Cladophora balls" alive in a small laboratory dish for eight years. She states that growth is slow and takes place both in a radial and tangential direction, probably in conjuction with the successive destruction of the older branches in the interior.

This results in some cladophora balls having a cavity at the centre caused by succesive destruction of the older branches. This is generally filled with water, but during May and April it contains a considerable amount of oxygen which enables the balls to float on the surface, while they remain on the bottom during the remainder of the year. Laboratory experiments by Wesenberg-Lund and Brand have been made in which the balls rise to the surface during strong illumination in the daytime and sink to the bottom in the evening and remain there on dull days. This novel peculiarity permits their wide dispersal in spring and early summer when they appear at the surface and become liable to transportation by winds, waves and currents to points remote from their place of origin.

From the foregoing it is evident that some "Cladophora balls" possess, with their diurnal ability both to float and rest on the bottom, a degree of mobility exceeding that of many aquatic animals. That they may transport at least fragments of plants other than algae is indicated by the photograph of some Lake Doré specimens, one of which has grown around a plant stem. It will appear from the following discussion that "Coal balls" were likewise endowed with an ability to move away from their place of origin. Some acquaintance with the mobility of the "Cladophora ball" may possibly help to understand the same quality in "coal balls."

"Coal balls." The nodular aggregations of various kinds of plant remains

preserved in calcareous and other kind of concretions found in certain coal beds are commonly designated as "coal balls." The excellent state of preservation shown by the included plant remains gives a particular interest to the question of the origin and history of these structures. "Coal balls" have a somewhat restricted distribution although it has been considerably extended during the last decade. They are unknown in the Nova Scotia field.[6] Until a few years ago they were almost unknown in the United States. But about ten years ago Professor Noé (1923, p. 385) announced their discovery in Illinois, Iowa, Kentucky and Indiana. Coal balls are known also from Austria, Czecho-Slovakia, Germany, Great Britain, Poland, Russia, and Australia. They are commonly found as brown or black lumps in the upper part of coal seams, and are frequently silicified or pyritized. Most of our knowledge of the inner structure of Paleozoic plants has been derived from the study of English and French coal balls. The distribution tables of Feliciano (1924, pp. 230-239) give coal balls known in England and Europe a range through both Upper and Lower Coal Measures while those found in the United States occur in both Allegheny and Post-Allegheny coal seams.

Two opposed hypotheses have been held in discussions of the origin of "coal balls" — the "in situ" theory and the drift hypothesis. The latter is strongly supported by the work of Jeffrey. In Jeffrey's (1900, p. 211) study of coal balls he found masses of charcoal distributed irregularly and without reference to stratification through the petrified substance of the ball. He cocludes that coal balls are not derived from material accumulated in situ and that the coals in which they occur "have been laid down under the open water and transport conditions which are universally conceded for the coals of the canneloid category." In presenting the evidence for open water conditions of coal ball formation Jeffrey offers no opinion as to the precise way in which the coal ball aggregations were assembled. But the open water condition of deposition to which his study lead invite comparison of Carboniferous lacustrine conditions and products with those of modern lakes.

The general absence from the coal balls of lines of lamination which are common in most coals and the varied character of the plant material assembled in these structures and its contrast with the aggregations of the beds in which they are found strongly sugges that the material forming the balls has been assembled in a different way from that of the beds holding the balls. Some have probably originated in the same way as the vegetable débris comprising the lake balls figured by Ganong (1907, p. 304) from New Brunswick and Massachusetts lakes. The oscillatory motion of waves under open water conditions would be likely to select from the bottom forest débris material which would lend itself most readily to moulding into ball like masses which might sometimes be transported some distance from their source. But more frequently they might be expected to become buried under bottom débris near the place of origin. If "lake balls" of our modern lakes such as Thoreau and Ganong have described, are the product of wave action they must have been formed on the bottom of Carboniferous lakes and lagoons quite as often as they are in modern lakes.

[6] Personal communication from Dr. W. A. Bell.

Stopes and Watson (1909, pp. 167-218) in their careful and detailed study of English coal balls have held to the "growth in situ" as opposed to the "drifted" origin of "coal balls." They have dealt apparently with structures some of which are quite different from those considered by Jeffrey. These include masses weighing tons allied in origin to the dolomite bed which supplants the coal seam in one mine where quite evidently vegetable and calcarous deposits accumulated side by side in the same lake just as they are doing today in various Ontario lakes. Some of their small "coal balls" (fig. 7, pl. 18) remind one strongly of the marl balls produced by lime separating algae in modern lakes. The conveniently vague and inclusive term "coal balls" as used by them embraces structures (fig. 7, pl. 18 and fig. 10, pl. 18) which appear to be syngenetic concretions comparable with those now forming in various lakes and often enclosing molluscan shells.

The shapes of the "coal balls" have sometimes departed so widely from the more common globular forms that they cannot be compared with "lake balls." Some of these may represent chunks of débris detached from floating islands or rafts.

The rafts or *embarras* which a century ago made navigation difficult in the lower Mississippi River and impossible in some of its large tributaries are probably comparable in their effects in damming streams to the work of timber rafts in Coal Measure times. Great stretches of some rivers were transformed into huge rafts of forest trees which one might cross without suspecting he was going over a river. Previous to 1816 the Atchafalfa river was covered by a raft for more than ten miles which was 220 yards wide and 8 feet deep. It rose and fell with the water and was covered with green trees and bushes some of which were about sixty feet high in 1835 (Lyell, 1887, p. 443). The Red river raft had attained a length of 124 miles when the U. S. Government undertook its removal in 1833. Twenty-two years later this task was abandoned in favor of improving the bayous for navigation, thus leaving "The Great Raft" in the marshes of the old river to be converted into a great peat bed and possibly "destined to become coal at some future geological period" as Reclus (1886, p. 270) suggests.

It seems clear that the dearth of oxygen in the water of sections of rivers blanketed by these timber rafts with their surface mat of vegetation would yield exceptional conditions for burial by sediments of plant remains where oxygen was nearly or quite excluded. Such conditions should result in fossil plants showing the perfection of preservation which is characteristic of "coal balls."

It is not such an unusual thing to see in certain Canadian lakes in midsummer floating compact masses of Chara and some associated plants which have apparently been detached from the bottom through the development of gases from vegetable decomposition. Comparable masses of floating vegetation may have at times dropped masses of plant assemblages in Coal measure lakes or lagoons which contrasted strongly with the bottom débris on which it grounded. Coal measures mud balls derived from cut banks of carboniferous lakes may also have played a part in supplying the aggregations known as "coal balls."

Summary: It has been the purpose of this discussion to direct attention to the novel structures known as "lake balls" and "cladophora balls" in seeking the origin and nature of "coal balls." It is inferred that "lake balls" were formed in Carboniferous times under the same conditions which now produce them and that some "coal balls" represent plant aggregations assembled in the same way that "lake balls" are now produced. The floating ability of "Cladophora balls" during the season of active growth has significance in connection with understanding the dispersal of some "coal balls" and their preservation in the midst of plant remains quite unlike those represented in the balls. Development of gases within the coal balls probably aided their wide dispersal just as gases generated during photosynthesis result in the migration of cladophora balls. Many of the structures called "coal balls" however, are not in any way related to modern "lake balls" or to "cladophora balls."

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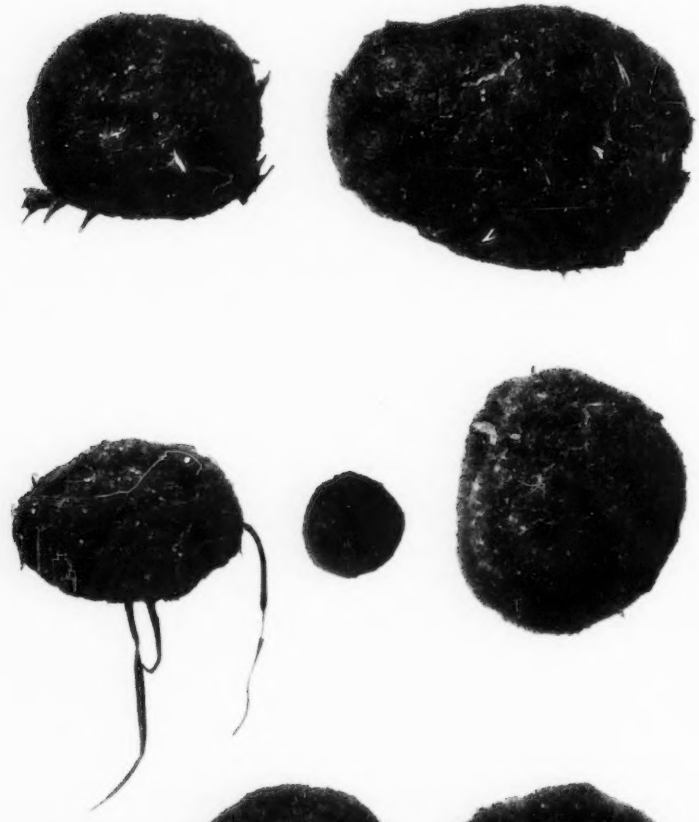

Fig. 2. "Cladophora balls,"—*Cladophora (Aegagropila) basaltica* Kütz.—from Lake Doré, Ontario, natural size. The two upper left hand balls show plant stems about which they have grown. The lower right hand figure shows radiating interior structure exposed by cutting through center of ball.

THE BRYOPHYTES OF THE CHASE S. OSBORN PRESERVE OF THE UNIVERSITY OF MICHIGAN, SUGAR ISLAND, CHIPPEWA COUNTY, MICHIGAN*

WILLIAM CAMPBELL STEERE

In October, 1929, the University of Michigan was presented by Ex-Governor Chase S. Osborn with several valuable tracts of land on Sugar Island, Chippewa County. It was intended that the tracts, which have a total area of over three thousand acres, be used for research and instruction in forestry and the natural sciences. The land is now under the management of the School of Forestry and Conservation.

Sugar Island, which is nearly 20 miles long, lies in the St. Mary's River between Ontario and the Upper Peninsula of Michigan. The northern end is much wider and higher than the narrow and more swampy southern end, where the largest part of the Osborn preserve is situated. The island is sparsely inhabited, and most of it has never been completely cleared, although, according to local tradition, little or no virgin forest remains. However, the original cutting was done so long ago that few traces of it are now evident. The present maple forests are exceedingly fine, and cover most of the uncleared higher land.

Through the kindness of Professor W. F. Ramsdell, the custodian, I spent most of June, 1933, on the large tract at the southern end of the island and occupied the cabin which the University received with the land.

One of the most interesting features of the southern end of the island is the terrace-like series of ancient beaches from much older and higher lake or river levels. These old shore lines, which are often separated by steep bluffs, appear to have a significant influence upon the forest cover and other vegetation. As previously mentioned, the highest and best drained parts are covered by a magnificent maple forest. The lower terraces are often quite flat, and as a result, poorly drained. Unless exceedingly wet, they are densely covered with balsam, birch and poplar. If the drainage is so poor that water accumulates, then there occur the various types of bogs and swamps characterized by cedar, spruce or black ash. Tamarack-alder swamps and open bogs and marshes apparently occur only at or slightly above the present river and lake level. Extensive stands of pine are not common. When present, they are, as a rule, limited to sandy or stony ridges.

Although outcrops of bedrock are exceedingly rare, there is no lack of rock. The whole southern end of the island seems to be built up of and covered by erratic boulders and rock fragments ranging in size from pebbles

*Papers from the Department of Botany and the Herbarium of the University of Michigan, No. 490.

to blocks six feet high. These boulders, in the humid forests, present a very favorable habitat for many bryophytes.

As a result of the high humidity and the varied habitats, the Osborn Preserve is peculiarly rich in mosses and hepatics. The high latitude and Canadian aspect of the flora add further interest to the bryophytes and to the plants in general. The whole aspect of the bryophyte flora is northern, and most of the species which are recorded here for the first time from Michigan are distinctly boreal ones. A matter of interest is the presence on Sugar Island of several mosses which heretofore have been known in the state only from Isle Royale.

The northernmost part of Chippewa County, particularly in the vicinity of Vermilion and along the south shore of Lake Superior, has been fairly well botanized (Dodge, 1921), although remarkably few bryophytes (8 species of hepatics and 29 of mosses) have been reported (Povah, 1928). A few of Povah's collections were reported much earlier by Kauffman (1915). There are apparently no other printed records of collections from the county. Mrs. C. D. Thorpe made a small collection of mosses on the northern end of the island in 1928. I have named these mosses and, for tthe sake of completeness, have included them here. Her collections are identified in the following list by the initials "F. J. T."

Species which are reported for the first time are marked with an asterisk (*).

I wish to thank Miss Margaret Fulford for naming some of the hepatics and for confirming my determinations of others.

Marchantiaceae

Conocephalum conicum (L.) Dumort. 3350. On moist, shaded bank along creek. Not common.

Marchantia polymorpha L. 3212. On sandy soil where wood had been burned.

Riccardiaceae

Riccardia multifida (L.) S. F. Gray. 3299, 3444. On rotting wood in swamps.

R. palmata (Hedw.) Carruth. 3316. On rotten wood, among mosses.

R. pinguis (L.) S. F. Gray. 3228, 3300, 3421. On rotten wood and wet shaded soil in swamps.

Pelliaceae

Pellia epiphylla (L.) Corda. 3339. Among mosses in bog.

Lophoziaceae

Chiloscyphus pallescens (Ehrh.) Dumort. 3370. On rotten wood and humus in swamp.

C. fragilis (Roth) Schiffn. 3399. In shallow, sluggish stream through black ash swamp.

Geocalyx graveolens (Schrad.) Nees. 3236, 3286, 3380, 3415. Common on rotten wood and humus in swamps and wet woods.

Harpanthus scutatus (Web. & Mohr) Spruce. 3456. On rotten wood in swamp; rare.

Jamesoniella autumnalis (DC.) Steph. 3241, 3262, 3284, 3379, 3381, 3385, 3430. Exceedingly common on rotten logs and shaded boulders.

Jungermannia lanceolata L. 3378, 3410, 3426, 3455. Not uncommon on humus and soil in moist places.

Lophocolea heterophylla (Schrad.) Dumort. 3244, 3287, 3462, 3464. Frequent on humus and rotten wood, often in open woods.

Lophozia barbata (Schreb.) Dumort. 3239, 3257, 3284. In large mats on shaded boulders. Frequent.

L. incisa (Schrad.) Dumort. 3304, 3305. On rotten wood in swamp.

L. porphyroleuca (Nees) Schiffn. 3282. On rotten wood in cedar swamp. Rare.

Plagiochila asplenioides (L.) Dumort. 3382, 3406, 3440, 3468. Frequent in wet woods on rotten logs and at the base of trees.

Cephaloziaceae

Bazzania trilobata (L.) S. F. Gray. 3202, 3246, 3380. Common on rotten stumps and logs in swamps and bogs.

Calypogeia Neesiana (Massal. & Carrest.) K. Müll. 3305, 3319. On rotten logs and humus in swamps, growing with mosses.

C. Trichomanis (L.) Corda. 3232, 3288, 3292, 3383, 3445. Exceedingly common on soil, humus, and rotten wood in swamps and wet woods.

Cephalozia curvifolia (Dicks.) Dumort. 3458, 3501. Not uncommon on decaying wood.

C. media Lindb. 3304, 3314, 3383, 3450. On rotten wood in moist places. Common.

C. pleniceps (Aust.) Lindb. 3474. On rotten wood in swamps.

Lepidozia reptans (L.) Dumort. 3235, 3305, 3376, 3385, 3473. Very common on humus and rotten wood in swamps, usually mixed with mosses.

Ptilidiaceae

Blepharostoma trichophyllum (L.) Dumort. 3296, 3396, 3445. Common on humus and rotting wood in moist places. Nearly always in rather small quantities and mixed with other bryophytes.

Ptilidium ciliare (L.) Nees. 3255, 3256. On shaded soil in forest.

P. pulcherrimum (Web.) Hampe. 3231, 3360. On fallen logs, at the base of trees and on stones in woods; common.

Trichocolea tomentella (Ehrh.) Dumort. 3293. On the ground in cedar bog.

Scapaniaceae

Scapania nemorosa (L.) Dumort. 3304, 3316, 3334, 3395, 3407, 3413. Very common on old logs, stones and bases of trees in wet and sometimes innundated woods.

Radulaceae

Radula complanata (L.) Dumort. 3297. On the bark of trees in cedar swamp.

Porellaceae

Porella platyphylloidea (Schwein.) Lindb. 3240, 3291. Common on soil, bases and trunks of trees in open woods.

Lejeuneaceae

Frullania eboracensis Gottsche. 3229, 3230, 3254, 3477. Exceedingly common on the trunks of trees in open woods and swamps, especially on *Betula alba* L.

Lejeunea cavifolia (Ehrb.) Lindb. 3475. On the side of a large boulder in swampy woods.

Sphagnaceae

Sphagnum recurvum Beauv. *F.J.T.* 14 (no data).

S. squarrosum Schwaegr. 3264. Common in cedar swamp.

Fissidentaceae

Fissidens osmundioides (Sw.) Hedw. 3318. On rotten log in cedar swamp.

Ditrichaceae

Ceratodon purpureus (L.) Brid. 3253; *F.J.T.* 31, 46. Common on soil in rather dry places.

Ditrichum pallidum (Schreb.) Hampe 3502. On soil in open woods.

Dicranaceae

**Trematodon ambiguus* (Hedw.) Hornsch. 3213, 3460. On sandy soil, in ditch along road; also in forest, on sand. Wherever this interesting species was found, it was abundant.

Dicranella heteromalla Schimp. 3388. At base of tree in rather dry woods.

Paraleucobryum longifolium (Ehrh.) Loeske (*Dicranum longifolium* Ehrh.) 3447, 3476; *F.J.T.* 50, 52. Occasional on large boulders in forest. This species has been previously recorded from Michigan only from Isle Royale (Holt, 1909).

Oncophorus Wahlenbergii Brid. 3298, 3343, 3403, 3480, 3491. Frequent in black ash swamps, on rotten logs.

Dicranum Bergeri Bland. 3219, 3301. In spruce and cedar swamps, associated with *Sphagnum*.

D. Drummondii C. Müll. 3359. On rotten log in woods.

D. flagellare Hedw. 3249. Common on decaying wood.

D. fuscescens Turn. 3326. On boulder.

D. montanum Hedw. 3360, 3404. Common; at the base of living trees and on logs.

D. scoparium (L.) Hedw. 3204, 3320; *F.J.T.* 50. Exceedingly common on soil, decaying wood, and humus covered rocks.

D. undulatum Ehrh. 3205. Frequent on moist sandy soil beneath pines.

D. viride (Sull. & Lesq.) Lindb. 3313. On decaying wood.

Leucobryaceae

Leucobryum glaucum (L.) Schimp. 3211; *F.J.T.* 61. Common in bogs and swamps; also on sandy soil in woods.

Grimmiaceae

Grimmia apocarpa (L.) Hedw. 3245, 3311, 3433. Common on boulders, both in the forest and in the open.

Rhacomitrium canescens (Timm) Brid. 3488. Over rocks and adjoining

dry soil. This species has been previously reported from the state only from Isle Royale (Cooper, 1913).

**R. microcarpum* (Schrad.) Brid. 3250, 3276, 3489; *F.J.T.* 16, 17. Apparently not uncommon on shaded or somewhat exposed boulders.

Funariaceae

Funaria hygrometrica (L.) Sibth. 3351, *F.J.T.* 67. On soil which contained fragments of burned wood.

Georgiaceae

Georgia pellucida (L.) Rabenh. 3210. Very common on decaying wood in swamps and wet woods.

Bryaceae

Webera nutans Hedw. 3227, 3315; *F.J.T.* 10, 69. Common on decayed wood and moist soil.

Leptobryum pyriforme (L.) Wils. 3402; *F.J.T.* 63. On peaty soil.

Bryum bimum (Schreb.) Brid. 3401, 3402. On wet soil in swamp.

B. caespiticium (L.) Hedw. 3354. Common on soil in dry, open places.

**B. cyclophyllum* (Schwaegr.) Bry. Eur. 3338, 3459. In very wet places, as at the margins of open roadside ditches, often actually in the water.

B. Duvalii Voit. 3265, 3356. On very wet soil, as at the edge of shallow brooks in forest, but not in the water.

B. intermedium (Ludw.) Brid. 3357, 3400. On moist sandy soil in forest.

Rhodobryum roseum (Weis.) Limpr. 3478. At the base of a tree in wet woods.

Mniaceae

Mnium affine Bland. var. *ciliare* (Grev.) C. Müll. 3309; *F.J.T.* 2, On soil in swamps and wet woods.

**M. cinclidioides* (Blytt) Hüben. 3321, 3333, 3437. Not uncommon in open bogs and open swampy woods. It is easily distinguished at sight from the other large *Mnia* by the black stems.

M. cuspidatum (L.) Hedw. 3216; *F.J.T.* 5, 49. Very common on shaded banks, and at the base of trees in open woods.

M. Drummondii Bry. Eur. 3425. On ground at edge of cedar swamp.

M. medium Bry. Eur. 3317, 3428. On damp soil and on rotten logs in swamps.

M. punctatum (L.) Hedw. 3344, 3392. On rotten logs and wet stones.

M. punctatum (L.) Hedw. var. *elatum* Schimp. 3202, 3348, 3355, 3429, 2457; *F.J.T.* 40. Very common on soil in swamps.

M. rostratum (Schrad.) Schwaegr. 3261; *F.J.T.* 26. On soil and rotten logs in swamps and wet woods.

M. spinulosum Bry. Eur. 3215, 3424; *F.J.T.* 6, 26. Common on humus-covered rocks and on soil in woods.

M. stellare Reich. 3353, 3420. At the base of trees in wet woods.

M. subglobosum Bry. Eur. 3306, 3332 3252, 3390. On soil and decaying wood in swamps; apparently always in small clumps. The only other Michigan record is that from Isle Royale (Cooper, 1913).

Aulacomniaceae

Aulacomnium palustre (L.) Schwaegr. 3252, 3278; *F.J.T.* 63. Very common on soil and decaying wood in wet woods and swamps.

Bartramiaceae

Philonotis fontana (L.) Brid. 3481, 3342. Frequent in open marshy places, especially along the river.

Orthotrichaceae

Ulota americana (Beauv.) Limpr. 3200, 3324, 3493. Occasional on large granite boulders. This species has been previously recorded from the state only from Isle Royale (Holt, 1908; Nichols, 1933).

U. crispula Bruch 3201. On the bark of trees.

U. Ludwigii (Brid.) Brid. 3323, 3500. On trees; not at all abundant.

U. ulophylla (L.) Broth. 3361. Common on the trunks of living and recently fallen trees in swamps and wet woods.

Orthotrichum Braunii Bry. Eur. (*O. strangulatum* Sull.) 3418a. On trees; rare. This has been previously reported only from southern Michigan. (Kauffman, 1915).

O. obtusifolium Schrad. 3427, 3496. Common on trees, and often very abundant.

O. ohioensis Sull. & Lesq. 3234, 3422, 3494. On trees. Widespread, but usually occurring in small quantities.

O. sordidum Sull. 3418, 3495. On trees; not frequent.

O. speciosum Nees 3233, 3434, 3490. On trees; the most common species of *Orthotrichum*. In black ash swamps it occasionally forms tufts on the tree trunks as large as one's fist. These remarkable tufts sometimes absorb so much water during a rain that they fall from the tree of their own weight.

Fontinalaceae

**Fontinalis antipyretica* L. var. *gigantea* Sull. 3412; *F.J.T.* 71 (no data). The only record for the species is from southern Michigan (Kauffman, 1915).

F. Lescurii Sull. 3412. No. 3412, which is a mixture of this and the preceding species, was growing between the stones of a dry, shingly beach in the outlet of an intermittent stream.

Climaciaceae

Climacium americanum Brid. 3349; *F.J.T.* 57. On soil and rotten wood in wet woods.

C. dendroides (L.) Web. & Mohr. 3258. On the ground in cedar swamp.

Hedwigiaceae

Hedwigia albicans (Web.) Lindb. 3371. One of the most common rock-inhabiting species, both in the forest and in the open.

Leucodontaceae

Leucodon sciuroides (L.) Schwaegr. 3208. Common on the trunks of trees in wet woods and swamps.

Neckeraceae

Neckera pennata (L.) Hedw. 3206, 3328; *F.J.T.* 65. On the trunks of trees in deep woods and in swamps. Common.

Homalia Jamesii Schimp. 3214, on large boulder; 3391, covering the base of a black ash tree in swamp. This species has been reported very recently by Nichols (1933).

Thuidiaceae

Anomodon attenuatus (Schreb.) Hüben. 3341. At the base of a tree in deep woods.

Thuidium delicatulum (L.) Mitt. 3209, 3308; *F.J.T.* 38, 70. On the soil and rotten logs in swamps and wet woods.

T. recognitum (Hedw.) Lindb. 3461. On the ground in open woods.

Amblystegiaceae

Campylium chrysophyllum (Brid.) Bryhn 3314. On rotten log in wet woods.

C. hispidulum (Brid.) Mitt. 3411. On rotten log in swamp.

C. polygamum (Bry. Eur.) Bryhn 3346, 3347. On the ground in swamp.

Leptodictyum trichopodium (Schultz) Warnst. 3268. On clayey soil in clearing. Previously reported only from Washtenaw County in southern Michigan (Steere, 1931).

Amblystegium Juratzkanum Schimp. *F.J.T.* 58 (no data).

A. serpens (L.) Bry. Eur. 3472. On rotten wood and humus.

Drepanocladus aduncus (Hedw.) Warnst. var. *Kneiffii* (Bry. Eur.) Warnst. 3466. In pool in deep woods.

D. fluitans (Dill.) Warnst. 3220, 3302. In sluggish brook in forest.

D. uncinatus (Hedw.) Warnst. 3270, 3307; *F.J.T.* 1, 3, 54. Frequent on soil, rotten logs, and boulders.

Calliergon cordifolium (Hedw.) Kindb. 3267, 3277, 3454, 3465, 3498; *F.J.T.* 37, Very common in swamps and in pools in wet woods.

Calliergonella cuspidata (Brid.) Loeske 3269. In bog, associated with *Sphagna.*

C. Schreberi (Bry. Eur.) Grout 3247; *F.J.T.* 41. Very common on sandy soil, stones, and logs in dry or wet woods.

Brachytheciaceae

Brachythecium campestre (Bruch) Bry. Eur. 3223, 3469. On boulders in forest. Previously recorded only from Washtenaw County in southern Michigan (Steere, 1931).

B. flexicaule Ren. & Card., 3483. On stone in forest.

B. oxycladon (Brid.) J. & S. 3398; *F.J.T.* 7. On base of tree.

B. populeum (Hedw.) Bry. Eur. 3222, 3485; *F.J.T.* 12. On boulders in woods.

B. reflexum (Starke) Bry. Eur. 3221, 3224, 3273; *F.J.T.* 22, 53. Exceedingly common on shaded boulders.

B. rivulare (Bruch) Bry. Eur. 3364, 3365. On wet soil in swamp.

B. rutabulum (L.) Bry. Eur. 3275; *F.J.T.* 19. On the ground in wet woods.

B. salebrosum (Hoffm.) Bry. Eur. 3443, 3484. On humus in swamp.

B. Starkei (Brid.) Bry. Eur. 3369. On rotten log in woods.

Bryhnia novae-angliae (Sull. & Lesq.) Grout 3272, 3310, 3325, 3340, 3448; *F.J.T.* 15, 18, 30. A common and variable species on soil and stones in wet places, especially along brooks in forest.

Eurhynchium strigosum (Hoffm.) Bry. Eur. 3327, 3363. On shaded banks, on soil and humus.

Plagiotheciaceae

Plagiothecium Roesanum (Hampe) Bry. Eur. 3217. On moist soil in forest.

P. denticulatum (L.) Bry. Eur. 3225, 3238, 3266, 3479. Very common on soil, humus, and rotten wood in woods and swamps.

**P. Ruthei* Limpr. 3463. On the ground in cedar swamp.

Sematophyllaceae

Heterophyllium Haldanianum (Grev.) Kindb. 3218, 3283, 3442; *F.J.T.* 4, 20, 28, 34, 36, 42, 43, 48. Very common on rotten wood, stones and at the bases of trees in wet and dry woods. In addition to the usual form, there is a well marked form with complanate leaves, which is easily distinguished by its larger size and much flattened stems and branches.

Brotherella recurvans (Michx.) Fleisch. (*Hypnum recurvans* Schwaegr.) 3368. On soil under tamaracks.

Hypnaceae

Platygyrium repens (Brid.) Bry. Eur. 3307. On fallen log.

Pylaisia polyantha (Schreb.) Bry. Eur. 3372. On trunk of tree.

P. Schimperi Card. 3227, 3373. Common on trees in woods.

P. subdenticulata Schimp. 3497. On trunk of tree.

Hypnum reptile Michx. 3226. On stones in forest.

H. imponens Hedw. 3366, 3393, 3397. On rotten logs and on fallen trees. Common.

Breidleria arcuatum (Lindb.) Loeske. (*Hypnum patientiae* Lindb.) 3345, 3367. On rotten logs in swamp.

B. pratensis (Koch) Loeske. (*Hypnum pratense* Koch) 3289. On the ground in tamarack-alder swamp.

**Isopterygium pulchellum* (Dicks.) Jaeg. 3312. On decaying wood in cedar swamp.

Taxiphyllum deplanatum (Sull.) Fleisch. 3285, 3387. On the ground in wet woods.

Ptilium crista-castrensis (L.) DeNot. 3203, 3248; *F.J.T.* 62. Common on soil, old logs, and stones in woods and swamps.

Rhytidiaceae

Rhytidiadelphus squarrosus (L.) Warnst. 3435, 3436. On rotten log in black ash swamp.

R. triquetrus (Hedw.) Warnst. 3290, 3358, 3482. Common on ground and humus in wet woods and swamps.

Hylocomiaceae

**Hylocomiastrum pyrenaicum* (Spruce) Fleisch. 3331, 3389. On old logs in cedar swamps.

Hylocomium proliferum (L.) Lindb. 3294. Very common on soil and rotten wood in wet woods and swamps.

Diphyciaceae

Diphyscium sessile (Schmid.) Lindb. *(Webera sessilis* Lindb.) *F.J.T.* 72. On soil.

Polytrichaceae

Catharinea undulata (L.) Web. & Mohr. 3259; *F.J.T.* 6, 23, 35. On the ground in woods and clearings.

Polytrichum commune L. 3207, 3260. On sandy soil in clearings.

P. juniperinum Willd. *F.J.T.* 59. In woods.

P. ohioense Ren. & Card. 3222, 3259; *F.J.T.* 59, 64, 68. On dry soil in open woods.

P. piliferum Schreb. 3251. Common on dry sandy soil in clearings and scrub forest.

P. strictum Banks 3329. Common in swamps and bogs, often with *Sphagna.*

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GRASSLAND IN THE FLOODPLAIN OF ILLINOIS RIVERS.

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Grassland in the floodplain of the rivers of Illinois has received the attention of several investigators. An interesting observation of an early explorer, Patrick Kennedy (-Imlay, 1797), is given by Gleason and is quoted herewith:

> About sunset we passed the river Demi-Quian.1 It comes in on the western side of the Illinois river (165 miles from the Mississippi); is 50 yards wide and is navigable 120 miles. We encamped on the southeastern side of the Illinois river, opposite to a large savanna, belonging to, and called the Demi-Quian swamp. The lands on the southeastern side are high and thinnly timbered; but at the place of our encampment are fine meadows, extending farther than the eye can reach, and affording a delightful prospect. The low lands on the western side of the Illinois river extend so far back from it, that no high grounds can be seen.

Gleason adds:

> Kennedy's whole narrative seems reliable, and we may believe that at least in some directions this camp commanded an uninterrupted view of the prairie. At the present time, however, the marginal belt of timber along the river in the vicinity of Havana is from 100 yards to a quarterof a mile (100 to 500 m.) wide, while the fringing woods along Quiver creek and large tracts of black oak completely cut off a view of the prairies. If Kennedy's statement is correct, then the large areas of timber have developed within the last century.

Brendel (1887) in his extraordinary work, Flora Peoriana, discussing the flora of the Peoria region says:

> We distinguish wet and dry prairies. The former in the river bottoms or in depressions of the dry prairies which occupy the high and undulating plain.

Hus (1908) mentions the absence of trees in excessive tracts in the Mississippi floodplains near St. Louis, Missouri, but attributes this to previous cutting. Sampson (1921) lists thirteen floodplain grass land areas in Illinois, mostly along the Mississippi and Illinois rivers and describes the various types of prairies and prairie successions occurring in the Mississippi valley near Savanna, Illinois.

The observed conditions occurring in the Mississippi and Illinois river valleys seem to be as follows: the customary floodplain forest is commonly confined to a belt or zone from a few hundred yards to a half mile in width paralleling the river channel or surrounding ponds and lakes. The landward site of this forest type merges into a grass association, at first on the hydric side of mesophytism, but giving way in turn, as the elevation of the floodplain increases, to a mesic grass association.

1 The Spoon river, joining the Illinois river opposite Havana.

The inhabitants of the lower Illinois river valley are of the opinion that essentially these conditions obtained at the time of earliest settlement. According to the testimony of the oldest inhabitants these grasslands were not denuded of trees by them, or by their white predecessors, but were as stated above. This information can be taken for what it is worth; the author although generally willing to discredit such evidence is inclined, in view of other circumstances, to attach some significance to it.

Two floodplain prairie areas are considered in this study. One tract of about 20 acres is in the lower Illinois river valley, near the mouth of Apple creek, in Greene county. The other is in the floodplain of the Mississippi river near Hillview, in Pike county. This latter area, although somewhat discontinuous, comprises several hundred acres.

Fig. 1. Floodplain prairie in the Hillview area. Forest-margined slough in the background.

Analysis of Prairie Sites

Topography

Topography obviously has an important bearing on the delineation of grassland from forest in the floodplain. This is because of its effect on the water content of the soil, soil aeration, flooding, and alluvial deposition. The following diagram illustrates this relationship between elevation and vegetation eype.

As a result of the topography of the floodplain four general plant zones are delineated: (1) the first, and lowest, is the hydric zone, i. e., the river channel, lakes, ponds and sloughs; (2) at elevations above this (two to six feet higher) which are almost annually flooded the floodplain forest occurs; (3) above zone 2 (two to six feet higher), in areas which are submerged only by exceedingly high flood water, occurs the low floodplain prairie; (4) the

remainder of the floodplain, better drained and seldom if ever flooded, is populated by a highfloodplain prairie type.

In view of the fact that flooding is one of the most important factors in limiting vegetation types it follows that resulting soil conditions (alluvial deposition and soil admixture) are also important. These shall be briefly discussed.

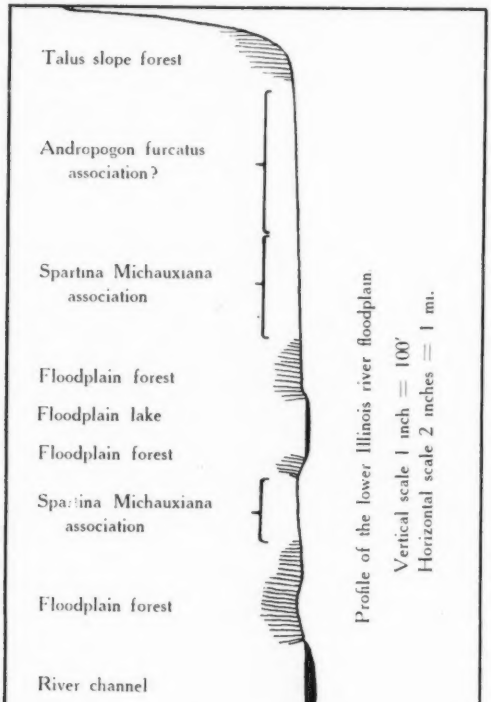

Fig. 2. Diagram to show the relationship between topography (elevation) and vegetational type in the middle Mississippi river and lower Illinois river valleys.

Soil

The soil of the lake and lake margin is a very finely divided type, i. e., *drab clay loam.*[2] On this grow the customary lake and lake margin plants of the region (Turner 1935). *Mixed loam* is the substrate of the next zone, the floodplain forest. Sometimes on this soil may occur the low prairie association, possibly in situations where the floodplain forest has been destroyed or some other factors have favored the invasion of the grass association. *Brown clay loam,* a mixture largely made up of soils washed from the adjacent uplands but containing considerable alluvial material, is the common soil of the next zone. It is on this soil that low prairie is more commonly found. *Brown silt loam* and *deep brown silt loam,* made up primarily of materials washed from the uplands, occur in the next zone. This area is of course better drained, rarely subject to overflow, and there is hearsay evidence that this zone was originally populated by a high prairie association in which Andropogons figured.

Unfortunately for this study the two soil types that were and still are associated with the prairie associations are those that have been farmed. This is speaking of the *brown clay loam* and the *brown silt loams.* At best the remaining stands of grasslands are remnants and much of the problem must remain in the field of conjecture.

Soil moisture, moisture equivalent, and wilting coefficient of soils. The above determinations were made during the growing-season of 1930. Although a dry year, the results obtained are nevertheless significant, particularly those pertaining to moisture equivalent and the wilting coefficient, the latter derived from the moisture coefficient. The following table[3] compares these characteristics of the soils of the low floodplain prairie to the floodplain forest, the floodplain-forest transition and the upland prairie of the region. Data are not available for the high floodplain prairie soils.

Table 1.

Station	Coefficient	Percent of water content of soils, depth 12"					
	Wilting	April	May	June	July	August	Sept.
Low floodplain prairie (Brown mixed loam)	16.7	37.2	20.9	24.1	22.5	21.6	26.7
Floodplain forest - prairie transition. (Brown mixed loam)	16.0	34.0	21.0	23.3	23.0	17.9	25.1
Floodplain forest (Mixed loam)	15.0	30.9	20.0	17.2	19.2	16.3	24.4
Upland prairie (Brownish yellow gray silt loam)	13.6	30.2	21.1	28.0	19.4	16.0	22.3

2 All soil data are from Soil Report No. IX, University of Illinois, Agricultural Experiment Station, and from soil maps of Calhoun, Pike, Greene, and Jersey counties, from the same source.

3 From "Plant Ecological Studies in the Lower Illinois River Valley. Turner."

The inferences to be derived from these figures are essentially orthodox, except possibly the ratio of soil water in the floodplain forest compared to that of the floodplain prairie. It will be observed that the soil moisture percentage was consistently higher in the floodplain prairie, although the former is at a lower elevation and its surface nearer the water table. Two factors explain this apparent paradox, the dryness of the season (with very little flooding of the bottomland forest and a low stage of water in the river) and the greater water exhausting power of the trees as compared to the grasses.

Soil reaction (pH). No significant differences in soil reaction were observed. The floodplain soils are consistently circumneutral with a tendency toward alkalinity. It seems safe to assume that this factor is not important in the delineation of vegetation types in this general habitat.

Evaporation

Data on evaporation (using the Livingstone Standard Atmometer) indicate an essential conformation with results obtained in comparable areas elsewhere. The low-prairie evaporation rate closely approximates that of the edaphic prairie of the Chicago region (Fuller, 1914), and that of the Minnesota and Nebraska low praries as described by Weaver and Theil (1917).

Summary Discussion of Environmental Factors

Aside from the periodic flooding of the low-prairie type the site probably does not differ greatly from other prairie sites in the central United States. And in regard to the water relationship it is recalled that the primitive, flat prairie land of Illinois was poorly drained to the extent that water stood in ponds and lakes for weeks and months in the spring and early summer.

Floristics

Vernal Aspects

The most conspicuous plants of April, May and June are the vegetative phase of the grasses and the few sedges that later dominate the habitat. These shall be discussed in connection with the summer and fall aspects; other typical low prairie plants occur as follows:[4]

Fairly common.

Cerastium arvense var. *oblongifolium*
Veronica peregrina
Alopecurus geniculatus
Stellaria media
Veronica officinalis

Occasional.

Eleocharis Engelmanni
Amsonia Tabernaemontana
Specularia perfoliata
Ranunculus abortivus
Myosurus minimus
Erigeron pulchellus
Erigeron philadelphicus
Potentilla monspeliensis
Apocynum cannabinum var. *pubescens*
Sisymbrium canescens
Festuca elatior

[4] The nomenclature used is that of Gray's New Manual of Botany, 7th Edition.

Rare.

Equisetum variegatum
Arabis virginica
Senecio glabellus
Agrostemma Githago
Brassica juncea
Viola Rafnesquii
Pentstemon laevigatus

The Summer Season

As the growing season progresses the small, ephemeral spring plants become less important members of the plant complex. Many wilt down due to the increasing competition afforded by the oncoming summer plants. In this competitive capacity the vegetative phase of the grasses and sedges is most important. However, a few of the more robust, early plants persist, some continuing to bloom well into the summer. Among these are Amsonia, Specularia, Apocynum, Potentilla and Pentstemon. Many summer plants become conspicuous for a time but are gradually obscured by the maturing tall grasses, *Spartina Michauxiana* and *Panicum virgatum*. Following is a list of plants that are blooming or active vegetatively during the summer period:

Fairly common.

Spartina Michauxiana
Bidens trichosperma
Cassia Chamaecrista
Eleocharis palustris
Ambrosia bidentata
Iva ciliata
Apocynum cannabinum var. *pubescens*

Occasional.

Alopecurus geniculatus
Eleocharis Wolfii
Steironema ciliatum
Vernonia missurica
Amsonia Tabernaemontana
Panicum virgatum
Oxalis corniculata
Potentilla monspeliensis
Festuca elatior
Specularia perfoliata
Euphorbia humistrata
Bidens comosa
Carex sp.
Calamagrostis canadensis
Convolvulus sepium
Stachys tenuifolia
Hypericum punctatum
Lythrum alatum

Rare.

Bromus secalinus
Penstemon laevigatus
Galium Claytoni
Spermacoce glabra
Teucrium canadense
Scutellaria lateriflora
Polygonum pennsylvanicum
Polygonum longistylum
Penthorum sedoides
Asclepias incarnata
Anthemis Cotula
Baptisia leucantha
Verbascum Blattaria
Bidens comosa
Phytolacca decandra
Chenopodium album
Bidens cernua
Lobelia cardinalis

Fall Aspect and Statistical Studies

During the first two weeks of September of 1930 a statistical study was made of the two areas under consideration. At this time essentially all of the summer plants were identifiable and the fall plants were mature enough to permit classification. Since time was not available for an elaborate quantitative evaluation of the habitat, the Raunkiaer frequency method was employed (Raunkiaer, 1918) as described by Kenoyer (1927). No defense or apology

for this system will be made, except to quote Romell (1930) to whom the author is in more or less agreement in this respect:

> . . . . statistical methods of the Raunkiaer type seem to still retain their value as a method of quantitative analysis of plant associations, which supply a golden mean between subjective estimation and more elaborate, exceedingly time wasting methods.

Methods. One hundred and ten plots (1 m.^{2}) were taken in the Mississippi valley area and fifty in the smaller Illinois tract. Subjective error was reduced by establishing lines through the areas and plots were examined every twenty-five yards.

Results. In the following table are shown (a) the important species and the percent of times occurring in 160 plots (frequency percent) and (b) the class in which each species falls. Following the customary procedure those species occurring in from 1 to 20 percent of the plots make up class A; class B includes those occurring in 21 to 40 percent; class C those in 41 to 60 percent; class D those in 61 to 80 percent, and class E those in 81 to 100 percent of the plots.

TABLE 2

Table of frequency percentage and class of species occurring in low-prairie areas according to the Raunkiaer method.

Species	Frequency percentage	
	Mississippi river valley area	Illinois river valley area
Class E.		
Spartina Michauxiana	100	82
Iva ciliata		82
Class C.		
Lythrum alatum		56
Cassia Chamaecrista	55	54
Bidens trichosperma	46	44
Class B.		
Ambrosia bidentata	31	38
Eleocharis palustris	36	28
Iva ciliata	36	
Euphorbia humistrata		36
Carex sp.		36
Stachys tenuifolia		34
Aster paniculatus		30
Apocynum cannabinum var. *pubescens*	29	
Eupatorium serotinum		28
Alopecurus geniculatus		26
Class A.		
Verbesina helianthoides		20
Panicum virgatum	19	
Panicum capillare	4	18
Steironema ciliatum	18	
Vernonia missurica	17	4
Steironema lanceolata		16
Alopecurus geniculatus	14	14
Solidago spp.		14
Carex sp.	11	14
Aster paniculatus	12	12

Oxalis corniculatus	11	12
Calamagrostis canadensis	11	2
Strophostyles helvola	11	2
Gerardia tenuifolia	2	10
Lythrum alatum	10	
Bidens comosa	10	
Apocynum cannabinum var. *pubescens*		8
Ipomea lacunosa	6	
Euphorbia humistrata	6	
Hypericum boreale	4	6
Echinochloa crusgalli	5	
Polygonum pennsylvanicum	5	
Stachys tenuifolia	5	
Physostegia virginiana	4	
Andropogon furcatus	4	4
Verbena hastata		4
Leersia oryzoides	3	
Stylosanthes biflora	3	
Panicum agrostoides	2	
Lepedeza capitata	2	
Convolvulus sepium	2	
Asclepias incarnata	2	

Other species occurring rarely.

Polygonum lapathifolium
Amsonia Tabernaemontana
Iris versicolor
Cuphea petiolata
Boltonia asteroides var. *decurrens*
Pentstemon laevigatus
Eupatorium serotinum
Baptisia leucanthus
Actinomeris alternifolia
Ambrosia trifida
Solidago spp.
Panicum dichotomiflorum
Bidens cernua
Bidens bipinnata
Erigeron canadensis
Eclipta alba
Cicuta maculata
Helenium autumnale
Amaranthus hybridus
Mentha arvensis
Bidens involucrata
Apios tuberosa
Cuscuta compacta
Setaria glauca
Cyperus spp.

Discussion of the table. Examination of the foregoing table shows that the tall slough grass, *Spartina Michauxiana,* is a conspicuous dominant in both areas. Other plants common to and important in both habitats are as follows: *Cassia Chamaecrista* and *Bidens trichosperma,* two small plants, are next in rank, in class 3. Third in frequency and in class 2, are *Eleocharis palustris* and *Ambrosia bidentata.* In class 1, and having frequencies raging from 17 to 4 percent are: *Vernonia missurica, Carex* sp., *Oxalis corniculatus, Calamagrostis canadensis, Strophostyles helvola, Gerardia tenuifolia* and *Hypericum boreale.*

In the two plots certain floristic differences and on the other hand striking similarities are revealed. Foremost among the differences is the occurrence of certain plants in a given class in one area and its absence in the other, or, a marked difference in frequency and rank in the two areas of certain plants. Illustrating this are *Iva ciliata, Lythrum alatum, Apocynum cannabinum* var. *pubescens, Euphorbia humistrata, Carex* sp., *Stachys tenuifolia, Aster paniculatus, Eupatorium serotinum, Alopecurus geniculatus, Verbesina helianthoides,*

Solidago spp., *Bidens comosa* and others. Similarities are: the complete dominance both in size and frequency of Spartina, the similar frequency of nine or more species, and the similarity in frequency of equivalent species such as *Panicum virgatum-P. capillare,* and *Steironema lanceolata-S. ciliata.*

A word of explanation might be made in regard to the difference in the areas that were mentioned above. In the Illinois river valley area Spartina is less frequent. *Iva ciliata,* a weed species, is more important, and in general there is a tendency for the ruderal species to occupy a more important position in this area. It was recognized that there were some differences in the physical and biotic factors of the two situations,—this area was not as well drained as the Mississippi valley area, water stood on it longer after floods, and it had been grazed to a small extent. Both of these circumstances would probably favor the weed species and discourage the grasses. Another difference, the smaller number of species in the Illinois river valley area, might be attributed to its smaller size and to the fact that not as many plots were examined on it.

In connection with the question of the importance of a grass, *Panicum virgatum,* a much discussed weakness of the Raunkiaer system is again evident. This species, although not having the frequency of distribution of several other species, is within the range of its occurrence a very important member of the association. The concentration, or absolute percentage of individuals is not indicated, of course. This same inadequacy of the system is evident in comparing *Spartina* with members of class 3: two species, *Cassia* and *Bidens trichosperma,* have frequencies approximately half that of *Spartina.* In no sense does this give a true picture of their relative dominance. The majority of plants in clases 2 and 3 are smaller (in this case many were seedlings of annuals that would never mature) and are relatively unimportant from a competitive standpoint. Other similar instances might be pointed out, but as stated before it is not within the premise of this paper to discuss the merits or deficiencies of this system of floral analysis.

This area bears considerable resemblance to the Spartina Michauxiana association in the Mississippi river valley near Savanna, as described by Sampson (p. 532 and 555, 1921) in his study of the prairies of that region. However, an interesting feature of the Hillview Spartina association, is the occurrence of members of other described associations, from both the hydric and xeric sides. Many plants of the more-hydric Carex veriscaria association of the Savanna area occur in this Spartina association of the Hillview area. Such species are: *Carex* spp., *Lobelia cardinalis, Steironema* spp., *Vernonia* spp., *Asclepias incarnata, Stachys tenuifolia, Eleocharis* spp., and *Leersia oryzoides.* Also occurring here is *Calamagrostis canadensis,* a species of the more xeric Calamagrostis canadensis association of the Savanna area. Of the Savanna Panicum virgatum association there are here present: *Panicum virgatum, Baptisia leucantha, Oxalis corniculata, Steironema* spp., *Physostegia virginiana,* and *Veronica virginica.* More surprising perhaps is the occurrence of species of the Savanna Andropogon furcatus association in the Hillview Spartina association. Such are: *Andropogon furcatus, Baptisia leucantha, Oxalis corni-*

culata, Lespedeza capitata, Veronica virginica, Vernonia missurica and *Ruellia ciliosa.*

These findings indicate two important and interesting phenomena. Obviously one is the adaptability or tolerance of some species to what seems to be a wide range of environmental conditions. The other is the apparent absence of definite steps in succession in this Hillview prairie site. From the time of the Scirpus fluviatalis association (also hydric pioneers here) to that of the Andropogon furcatus association, a heterogenous plant complex may occur. That is, plants of the climax association and of the various sub-climax (if there are stages) may appear quite early in the succesional process and subsequent events are the *gradual* establishment of more mesic and xeric and elimination of the more hydric species, as the habitat becomes more mesophytic.

Frequency Curve Comparison

It is not within the realm of this paper to discuss in detail the subject of the frequency curve. However, the following table is included in which is compared the normal frequency curve, as derived by Raunkiaer, curves derived by Kenoyer (1927) with those of the two areas under discussion.

Table 3

Area	Class				
	A	B	C	D	E
Raunkiaer's normal curve	53	14	9	8	16
Prairie (near Chicago)	19	3	1	0	2
Kenoyer's summary of the Chicago region	70	12	6	4	7
Mississippi valley low prairie	27	4	2	0	1
Illinois valley low prairie	13	8	3	0	2

It is noted that these two valley grass areas afford frequency curves which conform esentially to that of the Raunkiaer's, that is, the largest number of species fall in class A, less in class B and C, successively, D essentially equal to C, and E larger than D. As in Kenoyer's experience, however, there is a higher proportion of sporadic species (class A) and a lower proportion of dominants (class E) than is shown by the European curves. This is even more striking in the areas of this investigation than with those of the Kenoyer study.

There is little confirmation of Kenoyer's observation (Kenoyer, 1927, p. 345) "that as class A tends to be large, D tends to be larger than E," in this study. However, the present data are sufficient to warrant any conclusion in this respect.

Summary

1. Grassland possibly has been and may still be an important component of the floodplain flora of some parts of the upper Mississippi and the Illinois rivers.

2. The distribution of grassland in the floodplain and its delineation from floodplain forest seems to be controlled largely by topography and its effect on soil moisture and aeration and possibly to a lesser extent soil type.

3. The low-prairie, a step above the Scirpus and Carex stages in the successional sequence, is dominated by *Spartina Michauxiana*.

4. It is questionable if sharply defined steps in plant succession are discernible in the areas studied. Rather, there is obvious overlapping and merging of association types.

5. A floral analysis of the low-prairie areas by the Raunkiaer frequency method reveals an essential confirmation of the results of other users of this system. However, the results obtained more nearly coincide with those of Kenoyer (in the Chicago region) than they do with the results of the European investigators.

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A FOSSIL WILLOW FROM OHIO*

WILLARD BERRY

Last year I received from Mr. Russell Long, of Ada, Ohio, a small collection of plant material. It consisted of a piece of well preserved almost unaltered wood 2½ to 3 inches in diameter by several inches long; a mass of snarled and twisted bits of wood ranging from ⅛ to ¾ inches in diameter; and the major part of two small leaves. This material was collected from along Collins Run, in Section 26, Oxford Township, Butler Co., Ohio. Its geological age is not certain but is supposed to be between the Illinoian and the Wisconsin glaciation.

The woody materials were examined by Dr. W. H. Camp of Ohio State University, who reported that the large piece of wood is part of the vertical axis of spruce, probably *Picea canadensis* (Mill.) B.S.P. and that the rest of the woody material is roots mainly spruce but with the possible addition of tamarack *(Larix laricina* [DuRoi] Koch). Both of these plants have a present habitat in a cooler and damper area than exists today in southwest Ohio.

The two leaves (Figs. 1, 1a, 2) are referred to the willows, and appear to belong to the same species. They are referred to *Salix Uva-ursi* Pursh *(S. Cutleri* Tuck.). My thanks are due to Prof. Berry of Johns Hopkins University for checking this. The present range of this species is north of Ohio. It is found on high mountains in New York State, in Labrador, and the Hudson Bay region. Pursh [1] first described it from Labrador. In 1843 Tuckerman [2] recognized it under the name *S. Cutleri* and Emmerson reports it under Tuckerman's name from the Champlain Clays [3] of Hampshire Co., Mass. This occurrence in Ohio makes the second fossil record of this species in as far as I know.

These several fossils give us no clue concerning the age of the clays in which they occur other than that they are not recent. The fossils would seem to indicate that at the time they lived the conditions here were much cooler and probably damper than at present. The climate of southwestern Ohio would then probably have been similar to that which exists today north of the Great Lakes in the region of Hudson Bay.

Our leaves may be described as follows:

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* Read before the Ohio Academy of Science March 30, 1934.

1 Pursh, Flora Americae septentrionalis. London 1816, vol. 2, p. 610.

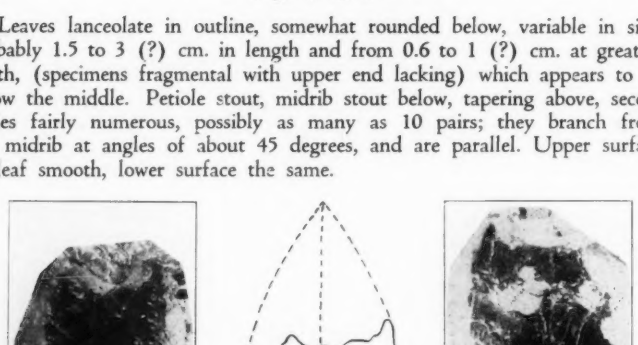
2 Tuckerman, Am. Jour. Sci. 1043, vol xlv. p. 36.

3 Emmerson, U. S. Geol. Survey Monog. 29, 1895, p. 719.

Salix Uva-ursi Pursh 1816.

Figs. 1, 1a, 2.

Leaves lanceolate in outline, somewhat rounded below, variable in size, probably 1.5 to 3 (?) cm. in length and from 0.6 to 1 (?) cm. at greatest width, (specimens fragmental with upper end lacking) which appears to be below the middle. Petiole stout, midrib stout below, tapering above, secondaries fairly numerous, possibly as many as 10 pairs; they branch from the midrib at angles of about 45 degrees, and are parallel. Upper surface of leaf smooth, lower surface the same.



For purposes of comparison the recent willows of Ohio are included to show that they could not be recent leaves imbedded in such a manner as to make them appear older than they are. The following list is from Grigg's "Willows of Ohio" [4] and Prof. J. Schaffner assures me that no new ones have been reported since that time. Griggs gives the following 20 species as occurring in Ohio. This does not include hybrids and sports but does include escaped foreign forms.

Salix nigra Marsh. Strong marginal veins, different in our fossils.

S. longipes Shuttlew. Veins hairy, different in our fossils.

S. amygdaloides Anders. Marginal veins, different in our fossils.

S. lucida Marsh. Leaves coriaceous, thick, different in our fossils.

S. pentandra L. European form of above.

S. fragilis L. Narrow, coarsely serrate, our fossils crenulate.

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4 Griggs, R. F. The Willows of Ohio. Proc. Ohio State Academy Sci. 1905, vol. 4, pt. 6, spec. no. 11, pp. 261-314, 16 pls.

S. alba L. Veins hairy, unbranched, different in our fossils.

S. babylonica L. Sharply serrate, our fossils crenulate.

S. interior Rowlee *(S. longifolia, S. fluviatilis)*. Serrate with distinctly spinulose teeth, crenulate in our fossil.

S. bebbiana Sarg. Veins strongly depressed, different in our specimens.

S. discolor Muhl. Coarsely serrate, blunt incurved teeth, different in our specimens.

S. humilis Marsh. Oblong or spatulate leaves with narrow base, different in our specimen.

S. sericea Marsh. Hairy leaves, glabrous in our specimens.

S. petiolaris Smith. Hairy leaves, glabrous in our specimens.

S. candida Fluegge. Veins deeply depressed, different in our specimens.

S. cordata Muhl. Leaves sharply serrate, crenulate in our specimens.

S. adenophylla Hooker. Surface hairy, glabrous in our specimens.

S. glaucophylla Beeb. Fine irregular veins, veins strong in our specimens.

S. pedicellaris Pursh. Leaves entire, serrate in our specimens.

S. purpurea L. Leaves entire or obscurely serrate, crenulate in our specimens.

As regards the young leaves which are more nearly the same size as our specimens, they are, as far as I can learn, usually all hairy. Ours show no evidence of a hairy surface.

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Notes and Discussion

MORE ABOUT ACER SACCHARUM MARSHALL

BENJAMIN FRANKLIN BUSH

In a previous issue of the AMERICAN MIDLAND NATURALIST,[1] I presented some reasons to show that the name *Acer saccharum* Marshall, could not be applied to *A. Treleaseanum* Bush; that the name is evidently a misprint for *A. saccharinum* Linnaeus; and, that Marshall's description applied to the Silver Maple, *A. saccharinum* Linnaeus. I stated further that Marshall described only four species of *Acer* in his Arbustum. For the sake of clarity, I should have added that my comments applied only to Sugar Maples.

In a recent issue of this same publication,[2] Dr. House takes exception to my statements about Marshall's species *saccharum* and attempts to show that the name applies to the Eastern Sugar Maple. In support of his opinion, he introduces several paragraphs of description from Marshall's Arbustum. My note intended to specify four of Marshall's species—*rubrum, Negundo, glaucum* and *saccharum*. The species *canadense* and *pennsylvanicum* were omitted because they are not Sugar Maples. As Dr. House says, Marshall made rather a mess of it when he wrote up the *Acer* species for his Arbustum. He evidently intended to follow the Linnaean nomenclature because he uses four Linnaean names. But only two names, *glaucum* and *canadense* are published as new.

The confusion in Marshall's nomenclature is further evident from the fact that he uses six names, only two of which, *Negundo* and *rubra*, being correct. Marshall's knowledge of the species of *Acer* is hardly better than his understanding of the genus *Vitis*. He describes four species of North American grapes as belonging to this genus. However, two of these species are certainly European, and the other two cannot be referred to their proper systematic position by any one known to the writer.

Dr. House gives four extracts from Marshall's description of *A. saccharum*. Any one of these would suffice to show that the species is not the Eastern Sugar Maple. The sentence, "the leaves something resemble the Silver-leafed Maple, but are not so large, nor deeply lobed," does not describe the Eastern Maple any more than it describes *rubrum* or *subglaucum* Bush. Marshall's statement "or of so fine a silver color" applies to some form of *A. saccharinum* but not to the Eastern Sugar Maple. Neither is it possible to apply to the Eastern Sugar Maple the words, "saccharum flowers in the manner of the Scarlet Maple but the flowers are of an herbaceous color." The Silver Maple does "produce large joined winged seeds," but the Eastern Sugar Maple produces no such seeds and has much smaller fruits.

A description that does not describe accurately is worthless. Nothing in Marshall's description of *saccharum* indicates that the Eastern Sugar Maple is meant, but the entire description fits *A. saccharinum* L. Even if Marshall had left good material or a good figure of his species, we should still be obliged to follow his description since this takes priority.

COURTNEY, MO.

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1 Am. Midl. Nat., 1931, vol. 12, pp. 499-503.
2 Am. Midl. Nat., 1934, vol. 15, pp. 76-77.

Book Reviews

THE MYXOMYCETES, by Thomas H. Macbride and G. W. Martin. New York: The Macmillan Company, 1934. ix+339 pp., 573 figs. in 21 pls.

Students of the *Myxomycetes* have long been familiar with the work of the senior author, the late Professor Macbride, whose editions of *The North American Slime Molds* appearing in 1899 and again in 1922 were at once accepted as authoritative, early establishing Professor Macbride as a keen student of this group of plants.

The responsibility for the present volume, *The Myxomycetes*, however must rest very largely with the junior author who bore the main burden of its preparation. In the main the volume has more than justified the expectancy with which those interested in *Myxomycetes* have awaited its appearance.

The authors chose to interpret the *Myxomycetes* in a strict sense, omitting the following groups from consideration: a) the *Acrasieae*, excluded also by a number of recent authors, yet retained by some in recent publications; the probable relationships of this group are not discussed; b) the *Plasmodiophoraceae*, which in general have been considered by recent authors to be more closely related to the Archimycetes, or at least to the lower Phycomycetes; the *Plasmodiophoraceae* were included in Macbride's 1922 edition of *The North American Slime Molds* as the sub-class *Phytomyxinae;* c) the Labyrinthuleae, which have been considered as being related to the *Myxomycetes* intermediate between the *Acrasieae* and true slime molds, but which are considered by others to belong to the *Protozoa;* and d) the *Hydromyxales*, a small group of aquatic forms including the genus *Vampyrella*, included in the *Myxomycetes* by some authors but excluded by most, pending further investigation.

"As here presented," state the authors, "the *Myxomycetes* are regarded as constituting the first and simplest class of the *Fungi*, coordinate in rank with the *Phycomycetes*, *Ascomycetes* and *Basidiomycetes*."

The Introduction of fourteen pages, following a resumé of the development of the taxonomy of the *Myxomycetes*, includes a brief account of the morphology of the two sub-classes considered, the *Exosporeae* and the *Myxogastres*, with clear definitions of a few terms of consequence such as *aethalium*, *plasmodiocarp*, etc. It will no doubt appear to some readers that a more extensive discussion of the morphology and physiology of the *Myxomycetes*, well illustrated, summarizing our present knowledge of the group along lines other than taxonomy, would have been a welcome contribution. Possibly a broader discussion of the relationships of the group as a whole would not have been amiss, as well as a discussion of the inter-relationships of the orders of the *Myxogastres*, which is limited to one short paragraph.

There is, however, a bibliography of broad scope emphasizing recent contributions both in morphology and physiology. It is also true that the purpose of this volume as stated in the subtitle is to give a descriptive list of the known species of *Myxomycetes*, with special reference to those occurring in North America. In this regard the authors have achieved a notable success. Sixty genera and about 370 accepted species are described. In addition to devoting considerable space in the text to synonymy, an appendix lists several pages of additional synonyms, names of species which are not *Myxomycetes*, but which have been included in the literature, and names of uncertain application.

The 573 figures grouped in 21 plates are either new or have been redrawn, the junior author having drawn all figures of spores, capillitium and other microscopic studies. All figures have been reproduced as half-tones rather than line drawings. An excellent feature is the fact that all drawings of spores have been reproduced at the same magnification, facilitating comparison of these significant structures.

The Myxomycetes will unquestionably assume a place of prominence in the hands of students of this Class of Fungi.—J. H. Hoskins.

MANUAL OF THE RUSTS IN THE UNITED STATES AND CANADA, by J. C. Arthur. Lafayette, Indiana; Purdue Research Foundation. 1934. xv + 438 pp., 487 figs., 1 map.

The geographic area covered in the preparation of this manual is that of Greenland, Newfoundland, Canada and the continental United States, including Alaska and the Aleutian Islands. Two families of the Uredinales are recognized, the *Melampsoraceae*, with 15 genera and some 87 species, and the *Pucciniaceae*, with 17 genera and some 400 species, of which 332 species are attributed to the genus Puccinia. Some 40 species are placed in five form-genera, which are described as being genera in which the aecial or uredial spore state is known, but not the complete life cycle. In addition Professor Arthur has included with brief descriptions 128 sub-tropical species which invade the United States along its southern border.

The author has attempted, in the arrangement of genera and species, to show degrees of relationship other than that indicated by hosts, an attempt which has resulted in the selection of what may be considered as "ancestral species," under which are grouped those species which exhibit correlation and which are believed to be reduced forms, without, however, losing their generic or specific identity. This has resulted in certain genera being divided into sections, rather than the sections being recognized as separate genera, and certain species being regarded as varieties rather than species. The numbered species in the manual are thus considerably reduced.

In addition to the key to species based on spore-forms, an index to hosts will be an aid in the identification of species when critical spore-forms are absent in the specimen.

Unfortunately lack of space necessitated certain omissions and curtailments emphasizing the difficulties in preparing an adequate manual of this group.

The 487 illustrations were adequately prepared by Mr. George Cummins. Those of the aeciospores, uredospores and teliospores have been reduced to a uniform magnification of 415 diameters.—J. H. Hoskins.

DIE FLECHTEN. Eine Einführung in ihre allgemeine Kenntnis auf Grund neuerer Forschungen und kritisch dargestellt von Dr. Friedrich Tobler. Jena: Gustav Fischer, 1934. iv + 84 pp., 66 figs., RM 5.50.

This little book presents in amplified form a series of lectures delivered at the University of London during Fall of 1931. The author summarizes our modern knowledge of the lichens with admirable skill, often taking exception to conventional ideas, and evaluating critically the contributions considered. His own researches and those of his students have led to new views which are justly considered in detail. Botanists will have to learn to change their ideas about this peculiar group on the strength of the evidence set forth. The approach and interpretation are primarily physiological. It may be of interest to quote here the criteria considered essential in recognizing a certain organism as a lichen: 1) Close connection probably as the basis for a more intimate material exchange; 2) development of a morphological structure of the appearance of a lichen different from that of closely related fungi; 3) physiological success of symbiosis, though not necessarily always subsequent to 2; 4) development of vegetative propagation. The reader will find much detail and a vast store of new information in this original and highly stimulating little book.—Th. Just.

THE LIFE FORMS OF PLANTS AND STATISTICAL PLANT GEOGRAPHY, being the collected papers of C. Raunkiaer. Oxford, at the Clarendon Press, 1934. xvi + 632 pp., 18 photographs and figures. 35s.

Collections of writings of outstanding investigators are always welcome. This volume should receive an enthusiastic welcome since so many of Prof. Raunkiaer's

papers have been for years inaccessible to most botanists because of difficulties of language and place of publication. It was therefore a real service on the part of the committee to secure the co-operation of three translators to assemble the collection found in the present book. While three papers in French and German were translated by Prof. A. G. Tansley (who also wrote a very enlightening general introduction) the bulk of the translation from the Danish was done by Mr. H. Gilbert-Carter of Cambridge, one heretofor unpublished paper having been translated by Miss A. Fausboll. The chronological sequence illustrates the general development of the system of life forms as proposed by the author.

The volume contains a wealth of interesting material particularly for the ecologist whose previous acquaintance with the work of Prof. Raunkiaer was ordinarily quite cursory. The book should be in the hands of all who are seriously interested in the present status of plant ecology both here and abroad.—TH. JUST.

THE FLORA OF THE NIAGARA FRONTIER REGION. (Ferns and Flowering Plants of Buffalo, N.Y., and Vicinity.) By Charles A. Zenkert. Bulletin of the Buffalo Society of Natural Sciences, vol xvi, x + 328 pp., 70 figs., 7 tables, 1 map.

Several local florae have of late appeared in the State of New York. The present volume, however, takes in parts of Canada and has additional chapters on the history of botanical exploration in the area concerned as well as detailed accounts of the regional environmental conditions, ecological areas and plant societies. The author displays a thorough knowledge of this area and its plant life, and in general presents an excellent summary of earlier work supplemented by his own explorations. The general appearance of the book, its good illustrations and its index of plant names are commendable features.—TH. JUST.

PALAOHISTOLOGIE DER PFLANZEN. Grundzüge einer Gewebelehre über fossile Pflanzen. Von Elise Hofmann. Wien: Julius Springer, 1934, vii + 308 pp., 153 figs. RM 25,20.

Dr. Hofmann has prepared an excellent outline for the study of fossil plants. It is in reality a general text-book of paleo-botany arranged to care for the needs of students having their introduction to this field of study. Thus while dealing with the same materials as other recent works on paleobotany, this book is distinctly different in point of view and in treatment. It makes little pretense of being a report of personal research, although the author is a well-known paleobotanist. It does emphasize, however, recent achievements through the orderly arrangement of facts and literature citations which both teachers and students find highly desirable in the more general work in any field of science.

The sequence of chapters is the logical one. Chapter 1 deals with the historical development of paleobotany as a science. Chapters 2, 3, and 4 treat in order the types of plant fossils available for study, the methods used in their study and identification and a consideration of tissue diagnosis. The chapter on methods will prove especially helpful to students, as it reviews briefly but accurately the various techniques of the paleobotanist, such as the maceration method, cellulose peel method and its numerous variations, the use of chemicals and dyes, etc.

The remainder of the book is given over to a systematic treatment of the plant kingdom as illustrated by fossil plants. A careful selection of figures illustrates the text, of which a considerable number make their first appearance here. A few could be improved upon.

A limited number of references is given as foot-notes in connection with the text. A comprehensive survey of the literature comprising some 29 pages follows the text. Its use is somewhat lessened by the fact that it is arranged in continuous lines which never facilitates the finding of a desired reference.—J. H. HOSKINS.

SIXTH INTERNATIONAL BOTANICAL CONGRESS
AMSTERDAM 1935

Motions dealing with Nomenclature for consideration by the Congress should be sent, before January 1, 1935, to Dr. T. A. SPRAGUE, The Herbarium, Royal Botanic Gardens, Kew, Surrey, England, who has undertaken to collate and report on them at the request of the Executive Committee of the Congress, and the Executive Committee for Nomenclature, no Rapporteur général having been appointed at Cambridge.

Motions must be presented in the form of additional articles (or amendments) to the International Rules, ed. 3, the English text[1] of which may be obtained from Messrs. TAYLOR and FRANCIS, Red Lion Court, Fleet Street, London E. C. 4, at the price of 2 s. They must be drafted as briefly as possible in Latin, English, French, German, or Italian. At least 100 printed copies must be presented.

Only motions relating to new points which were not settled at previous Congresses can be presented. Motions not complying with these conditions will not be discussed unless the Amsterdam Congress 1935 decides to take them into consideration.

In accordance with the decision of the Cambridge Congress, the changes in the Rules made by that Congress will be considered at Amsterdam for confirmation, amendment, or rejection.

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1 The edition in three languages (English, French, German) is in print and will shortly be published with examples and lists of names by GUSTAV FISCHER, Jena.

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